Understanding Air Pollution Transport

2002 Ozone Transport Commission Annual Meeting

OTC Modeling Committee – Transport Workgroup

Presented by:

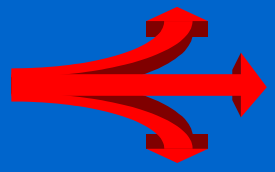
Jeffrey Underhill, Ph.D.

NHDES

August 6, 2002

The Basics of Air Pollution Transport:

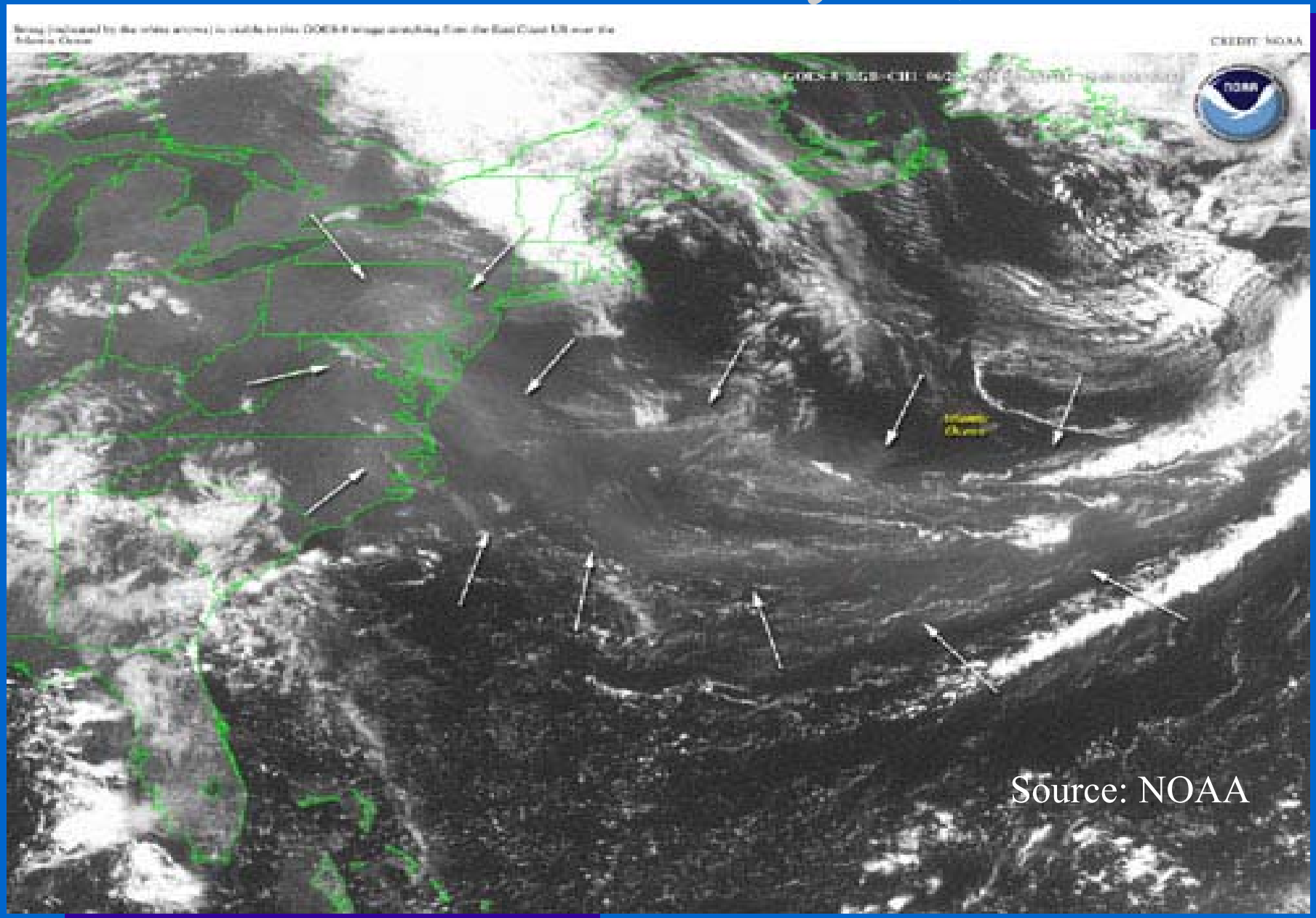
1. Start with the Wind.
2. Just add pollution.
3. Air pollution blows downwind.



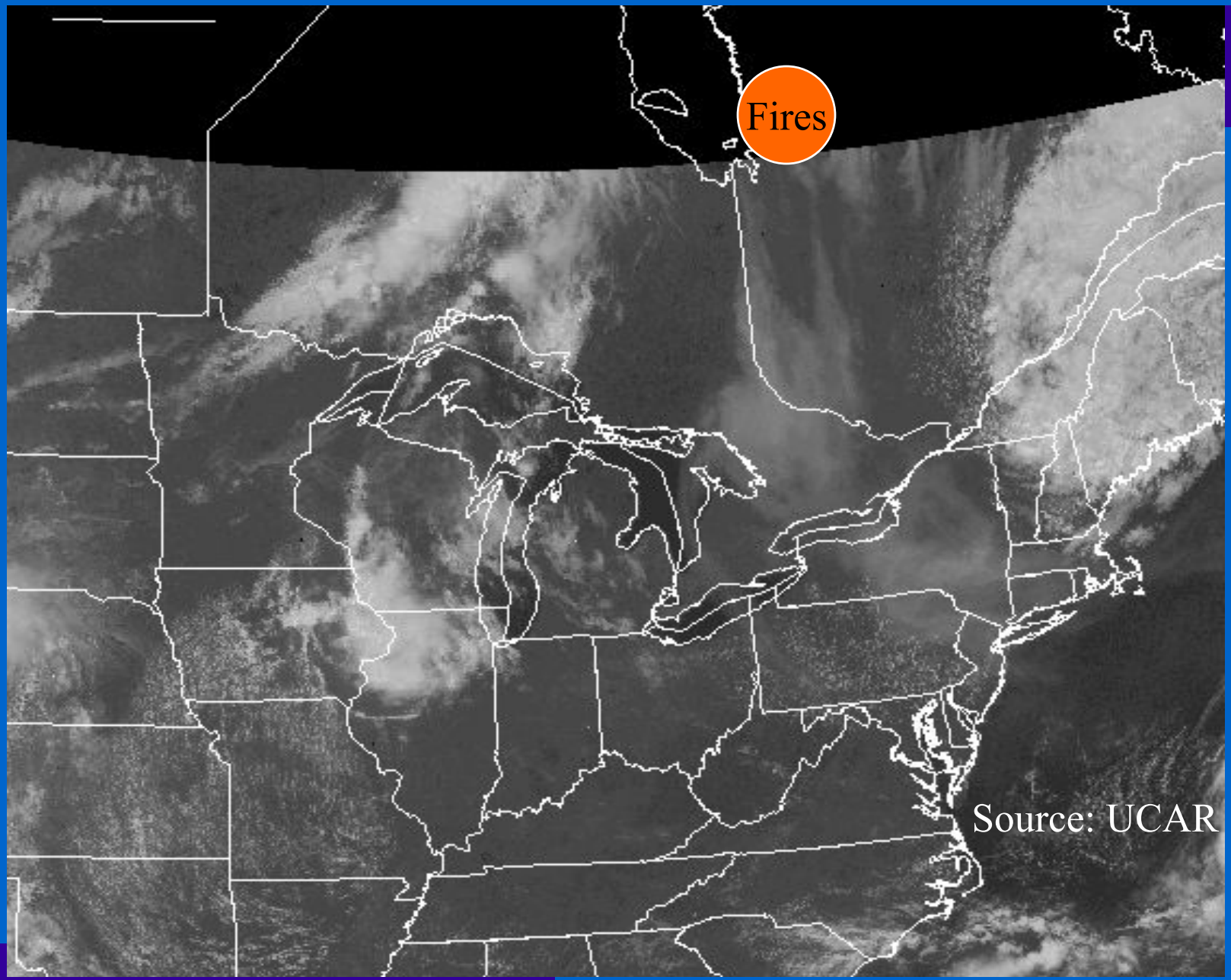
Congratulations! You have transport!

Classic Examples of Transport

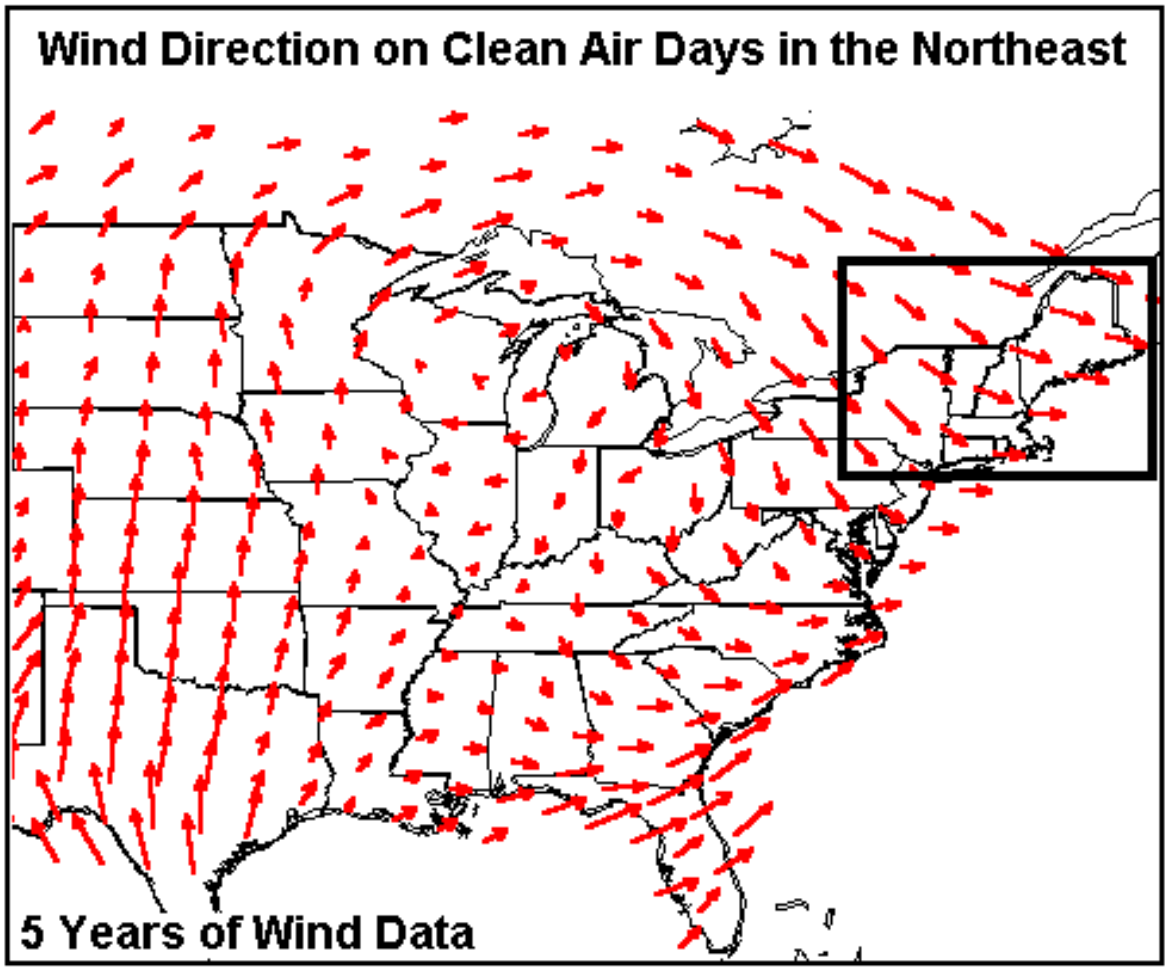
Sulfate Cloud – July 27, 2001



Canadian Fires – July6, 2002

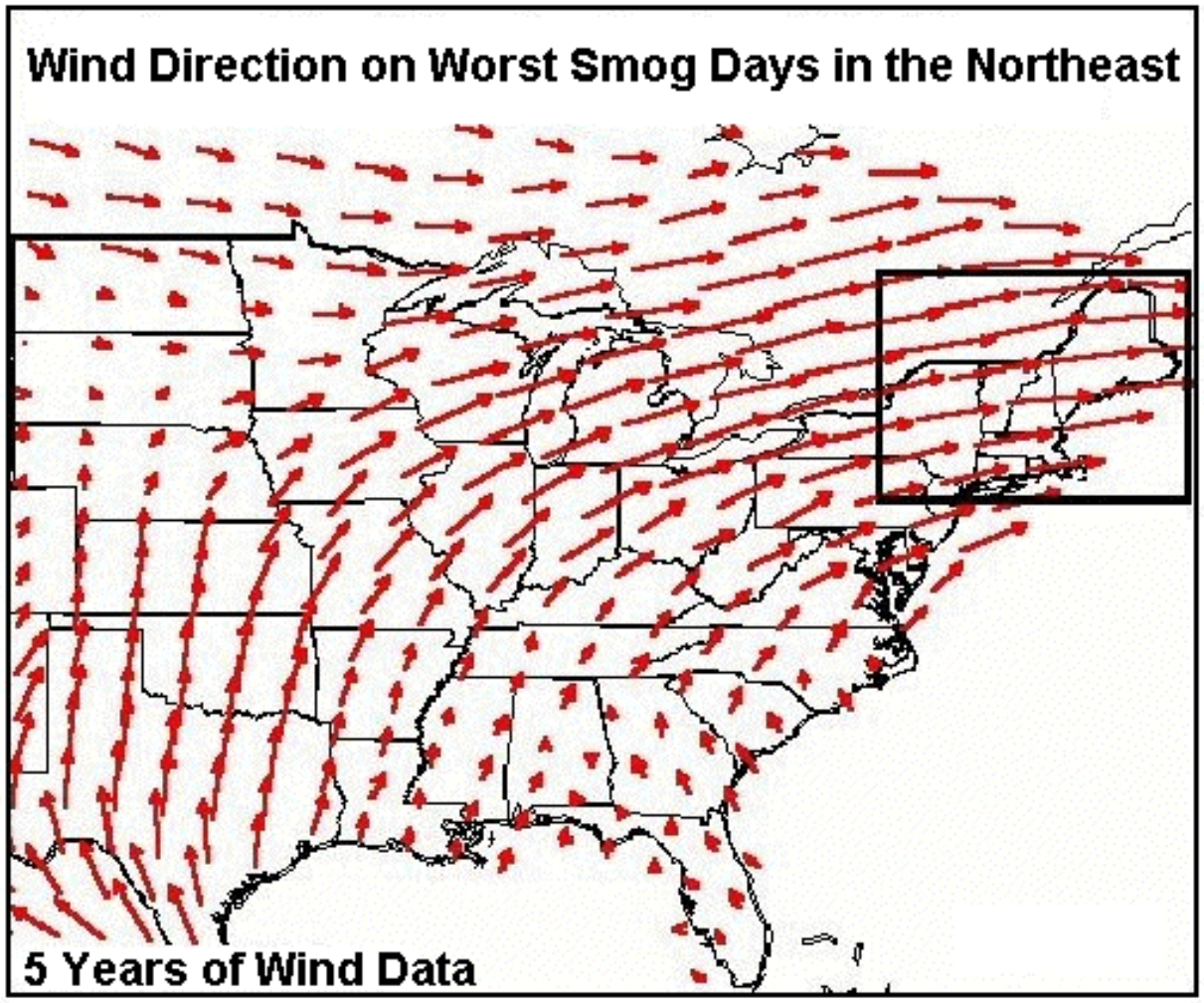


The Wind – Good!



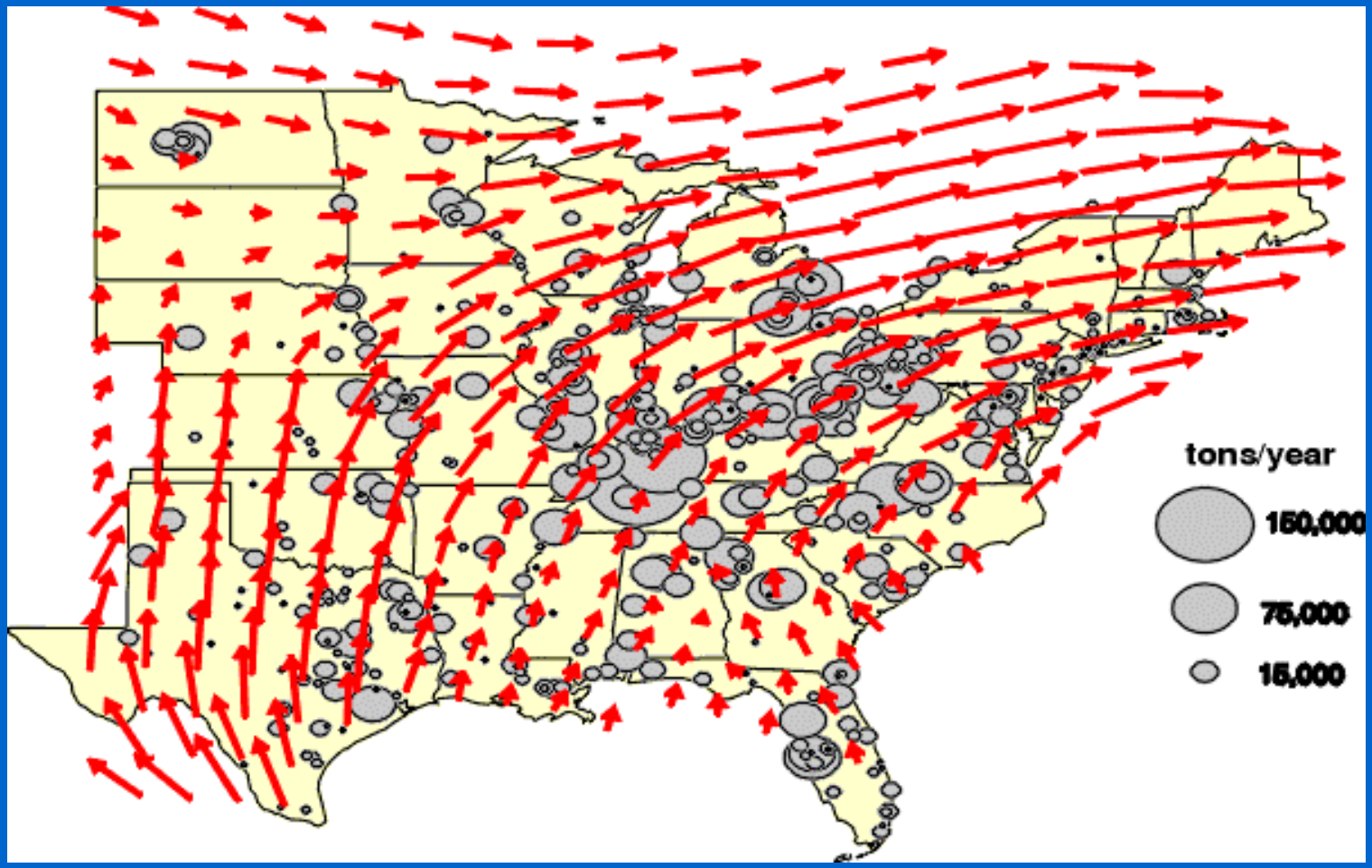
Source:
NESCAUM

The Wind – Bad!



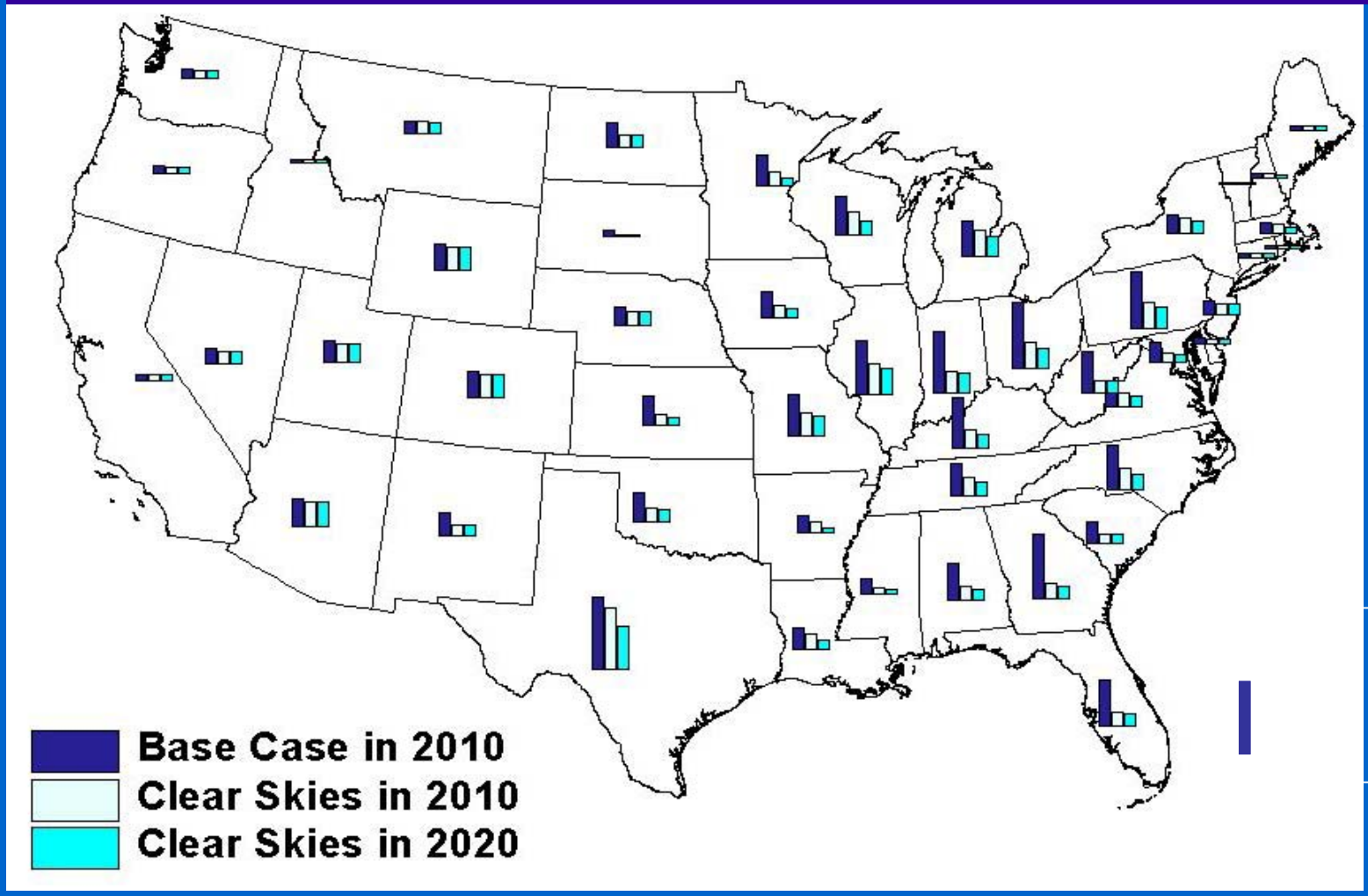
Source:
NESCAUM

Wind patterns when high ozone episodes occur in the Northeast; locations and NOx emissions of electric generating plants



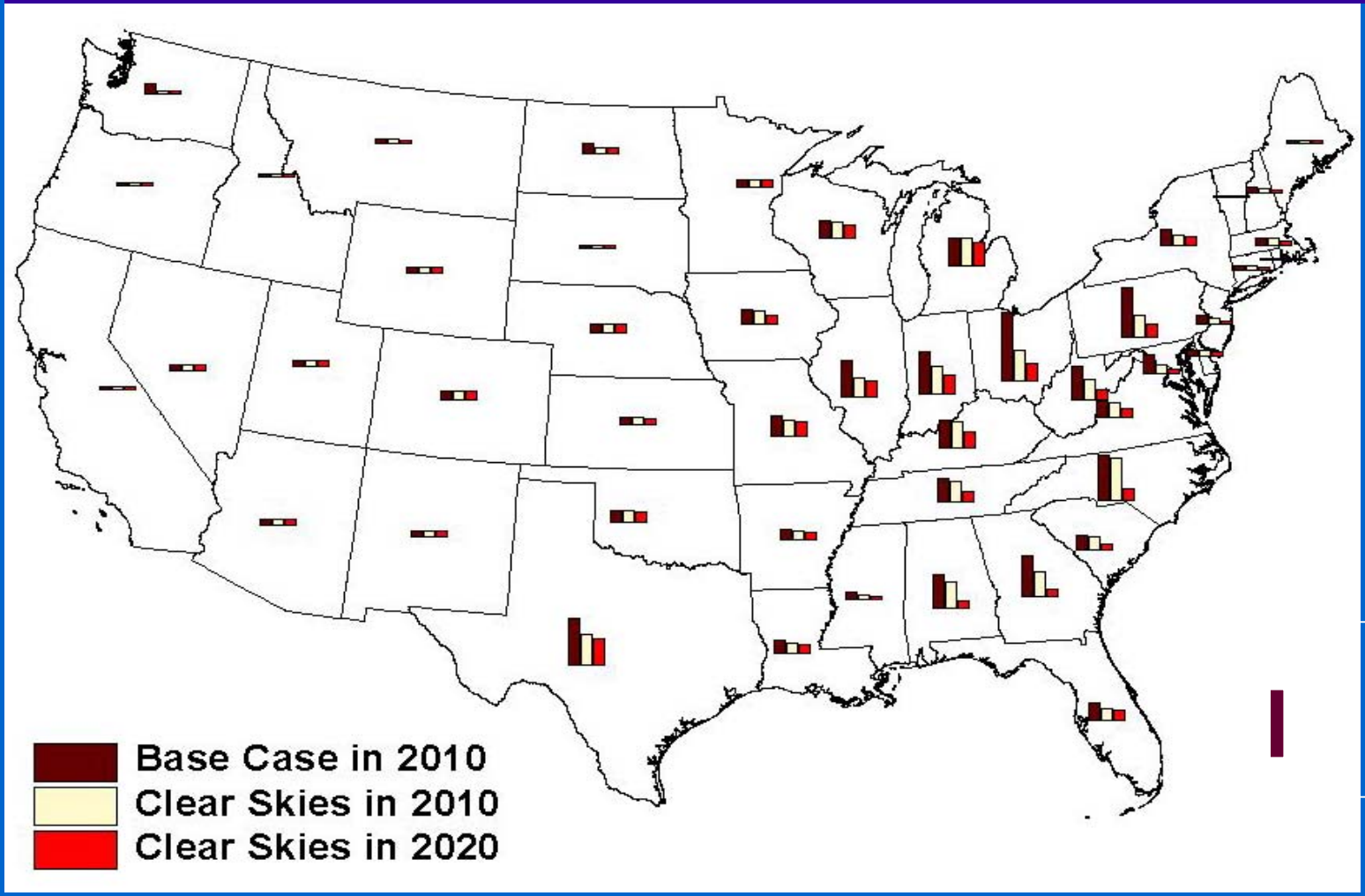
Source: CTDEP

Areas Adding Pollution (NOx)



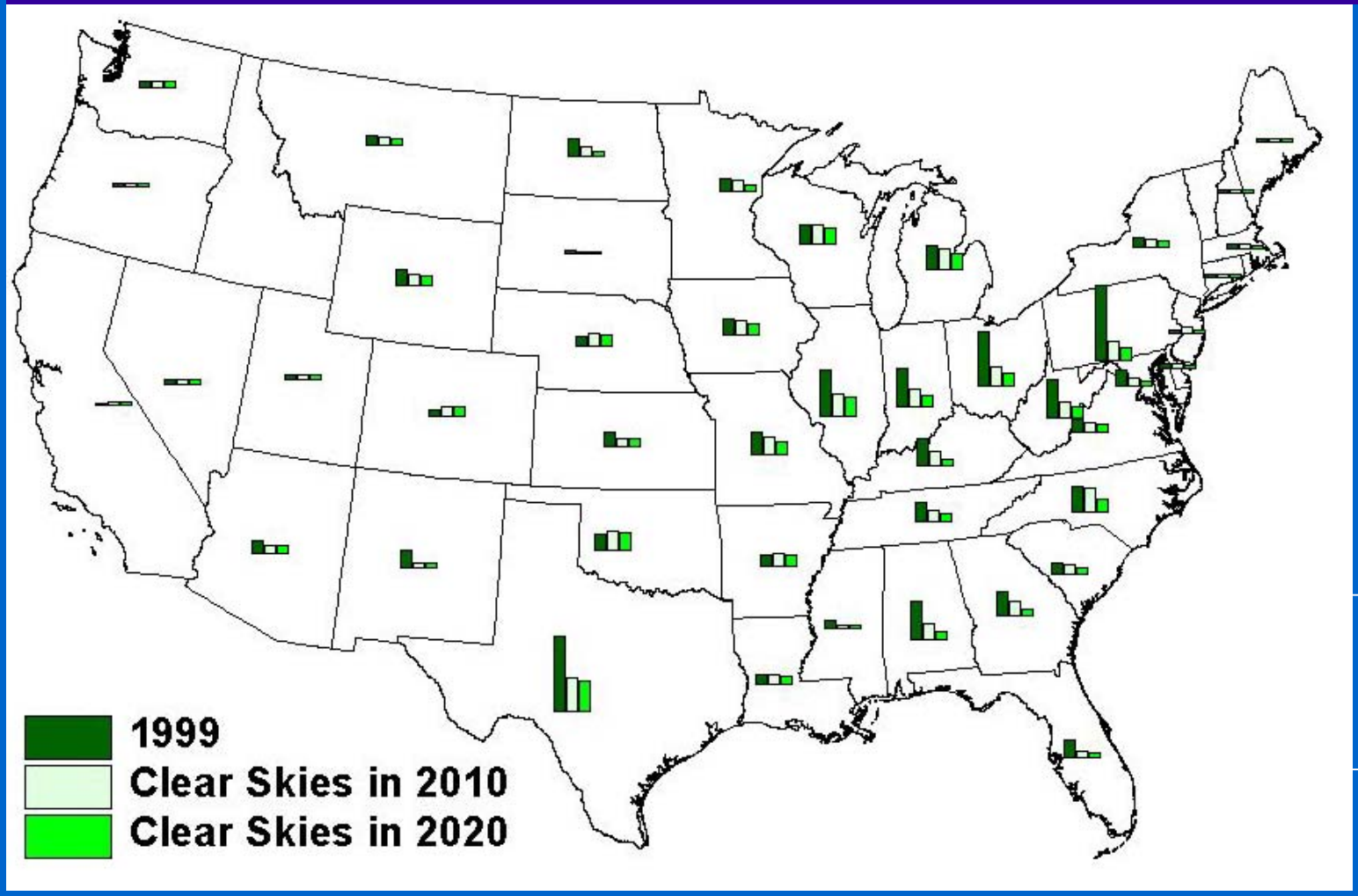
Source: EPA

Areas Adding Pollution (SO_2)



Source: EPA

Areas Adding Pollution (Mercury)



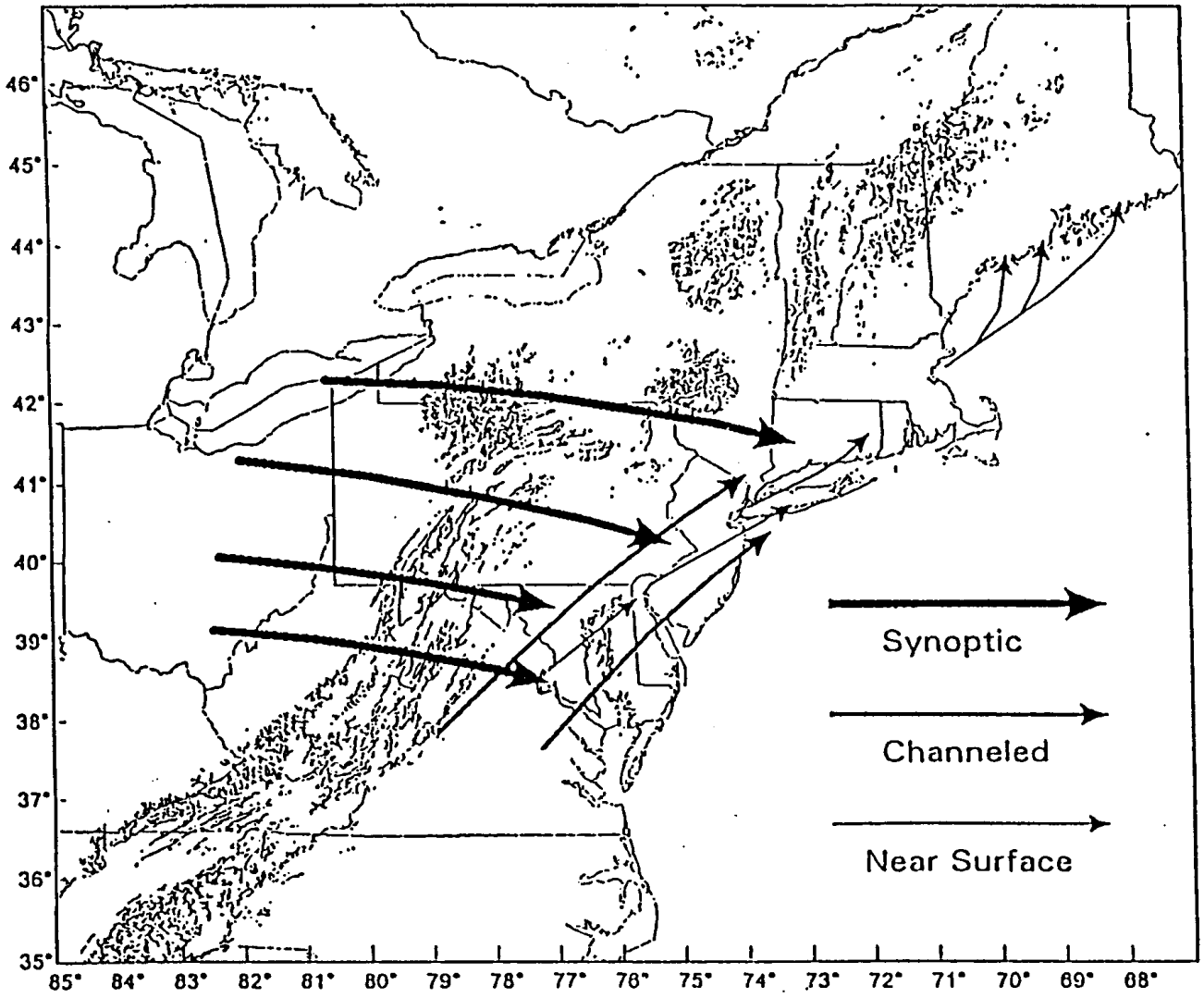
Source: EPA

Ozone and Particulate Matter

Formation and Transport

- The Ozone Transport Assessment Group (OTAG) composed of 37 states, EPA, researchers, and other stakeholders assessed four regionally severe ozone episodes to study the mechanics of transport.
- OTAG documented the existence of transport and outlined steps to reduce ozone transport intended to lead to attainment.

3 Basic Transport Regimes



Transport Regimes Observed During NARSTO-Northeast

Source: NARSTO-Northeast

High Elevation Transport

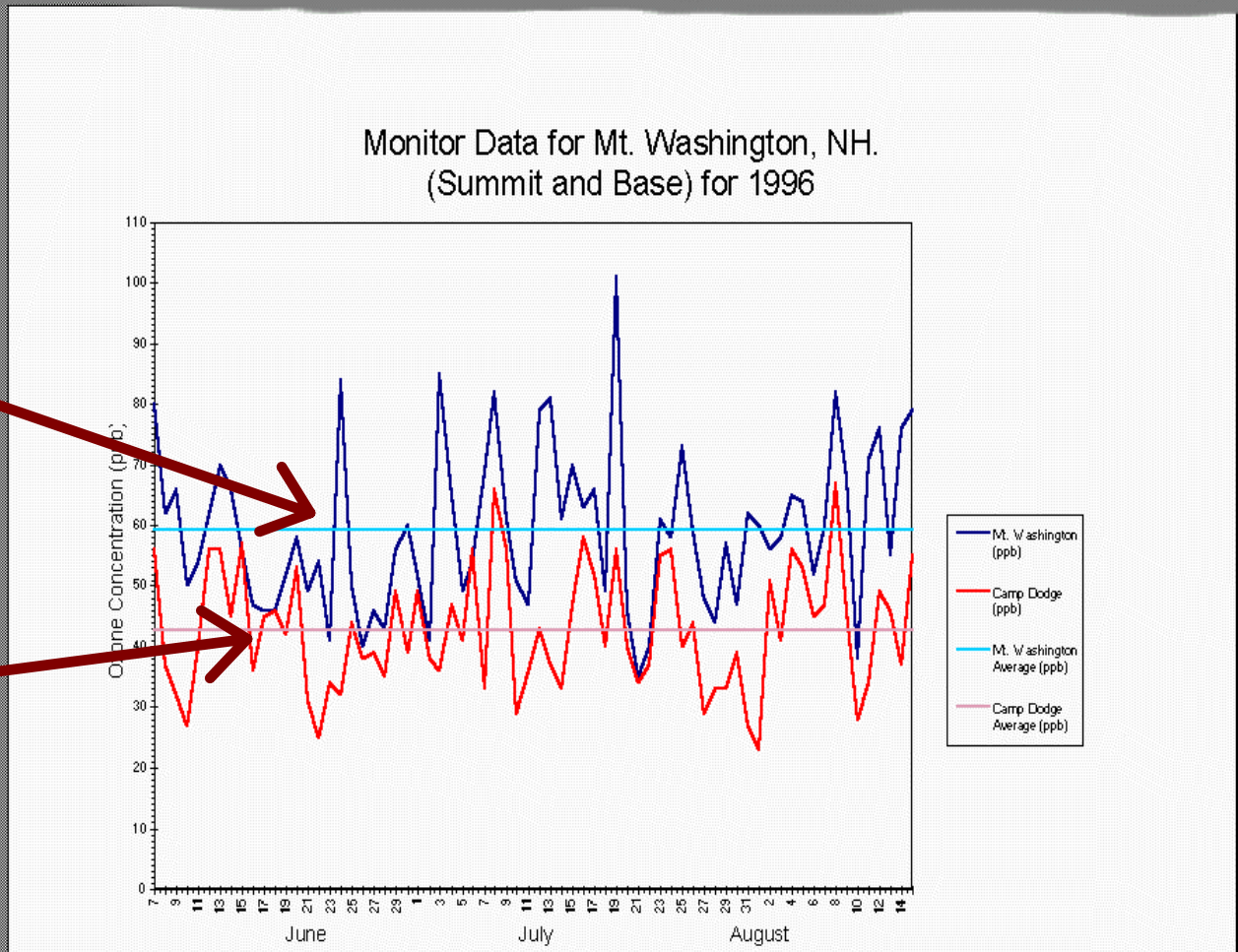
- Follows flows of large-scale weather features
- Transport is often at high speeds when near the jetstream
- May be prevented from mixing down to ground level by thermal inversion
- Often shows in airplane or mountain-top monitoring
- Down-mixing may occur 100's to 1000's of miles downwind

Ozone Transport: Mt. Washington Summit and Base

Summit ozone concentrations are often higher than it's base

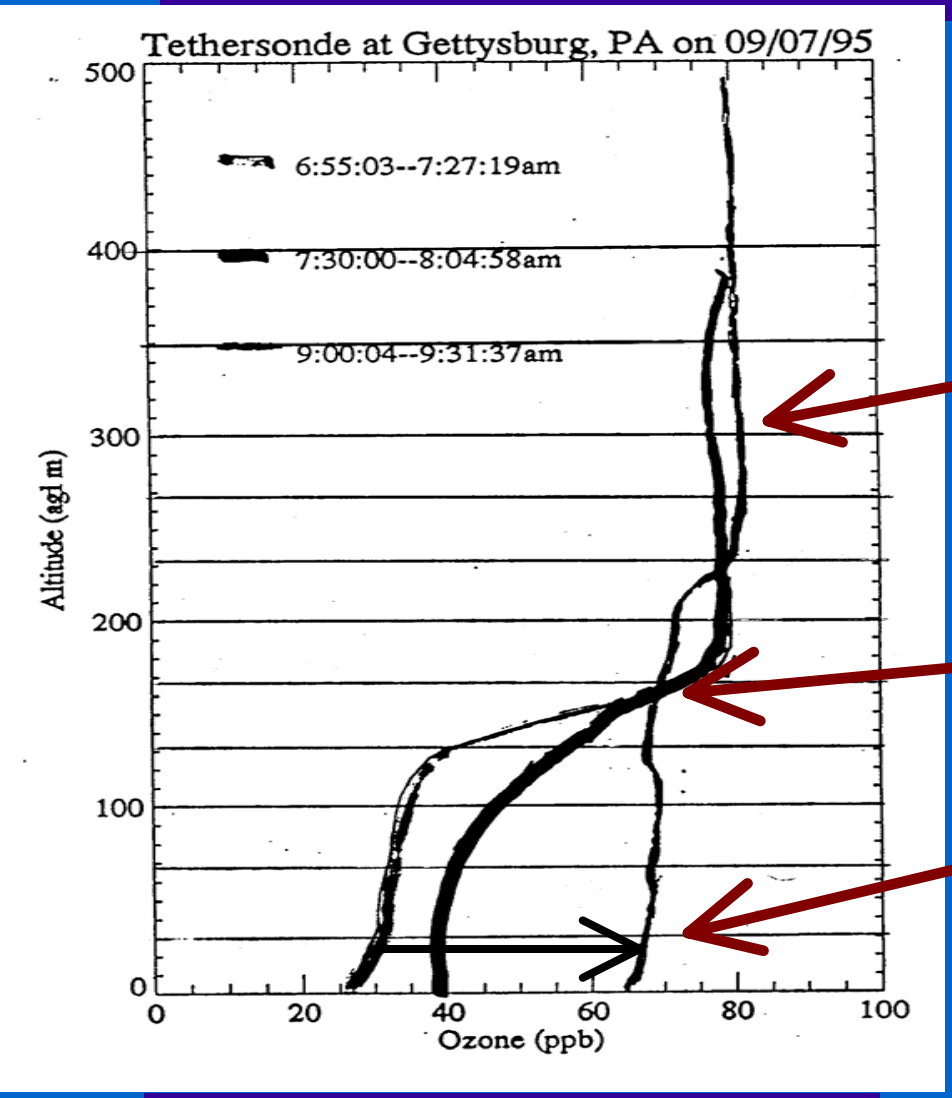
Mt. Washington Summit (6288ft)

Mt. Washington Base (~2000ft)



Source: NHDES and AMC

High Elevation Transport: Vertical Ozone Profile



Ozone transporting above thermal inversion

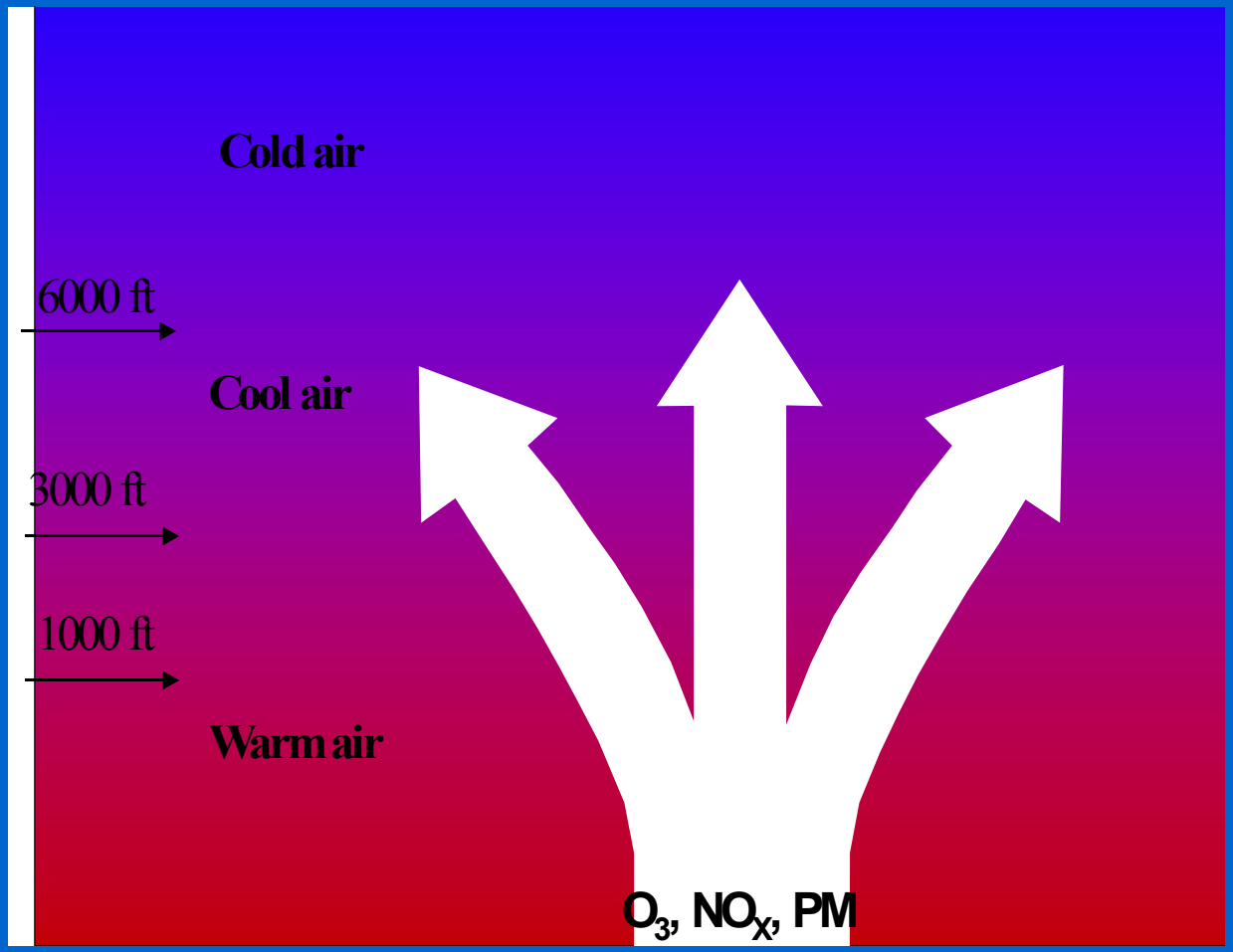
Level of Inversion

Ground level ozone increases as ozone mixes downward after inversion breaks-up

Source: NARSTO-Northeast

Typical Daytime Temperature Profile

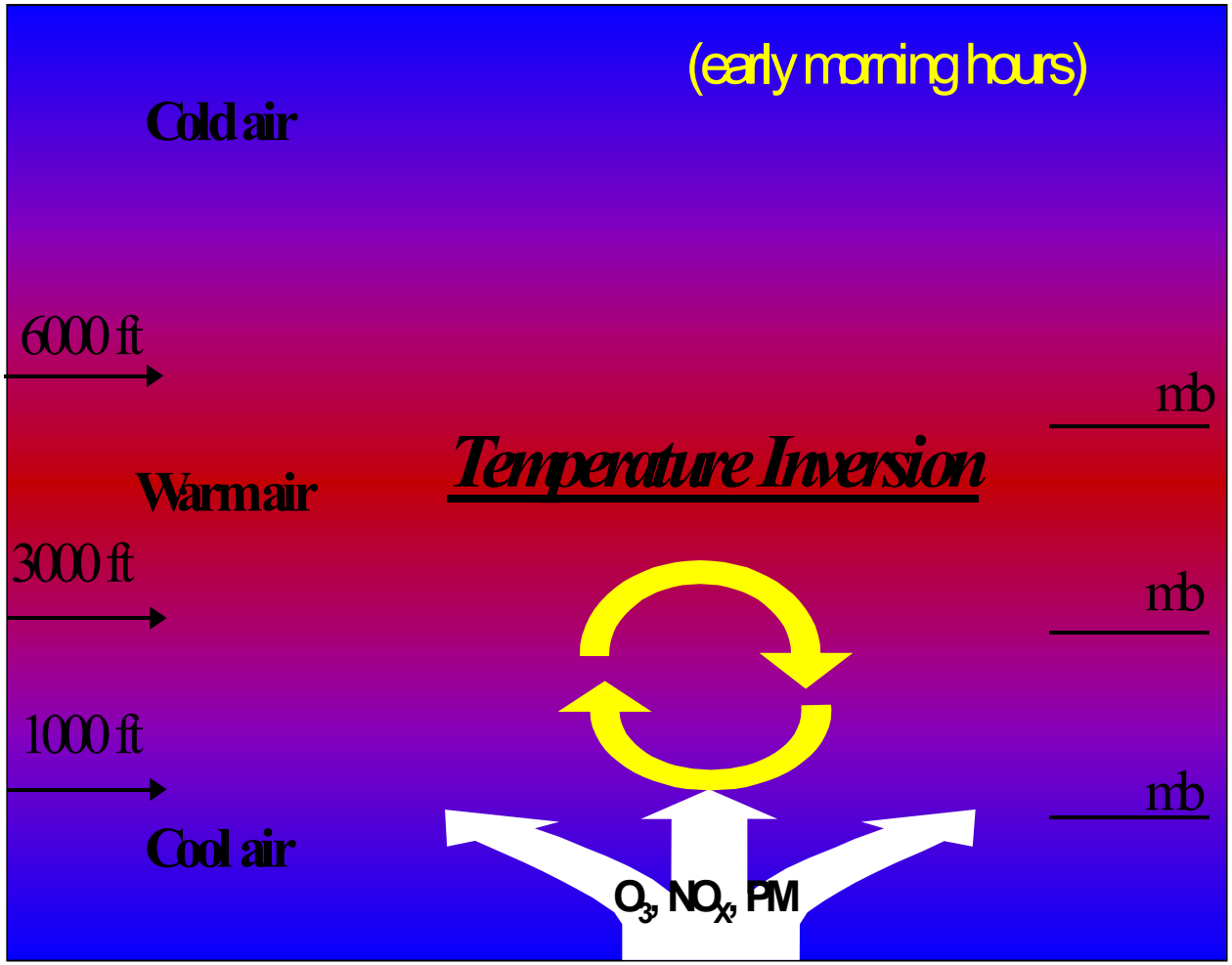
- Ground warms from sun's heating
- Air above is cooler
- Warm air rises
- Mixing occurs – diluting concentrations
- Allows for high elevation transport



Source: MDE and UMD

Temperature Inversion

- Cool air will NOT rise into warm air above
- Temperature inversions inhibit vertical mixing – keeping pollution concentrated
- Low-level transport



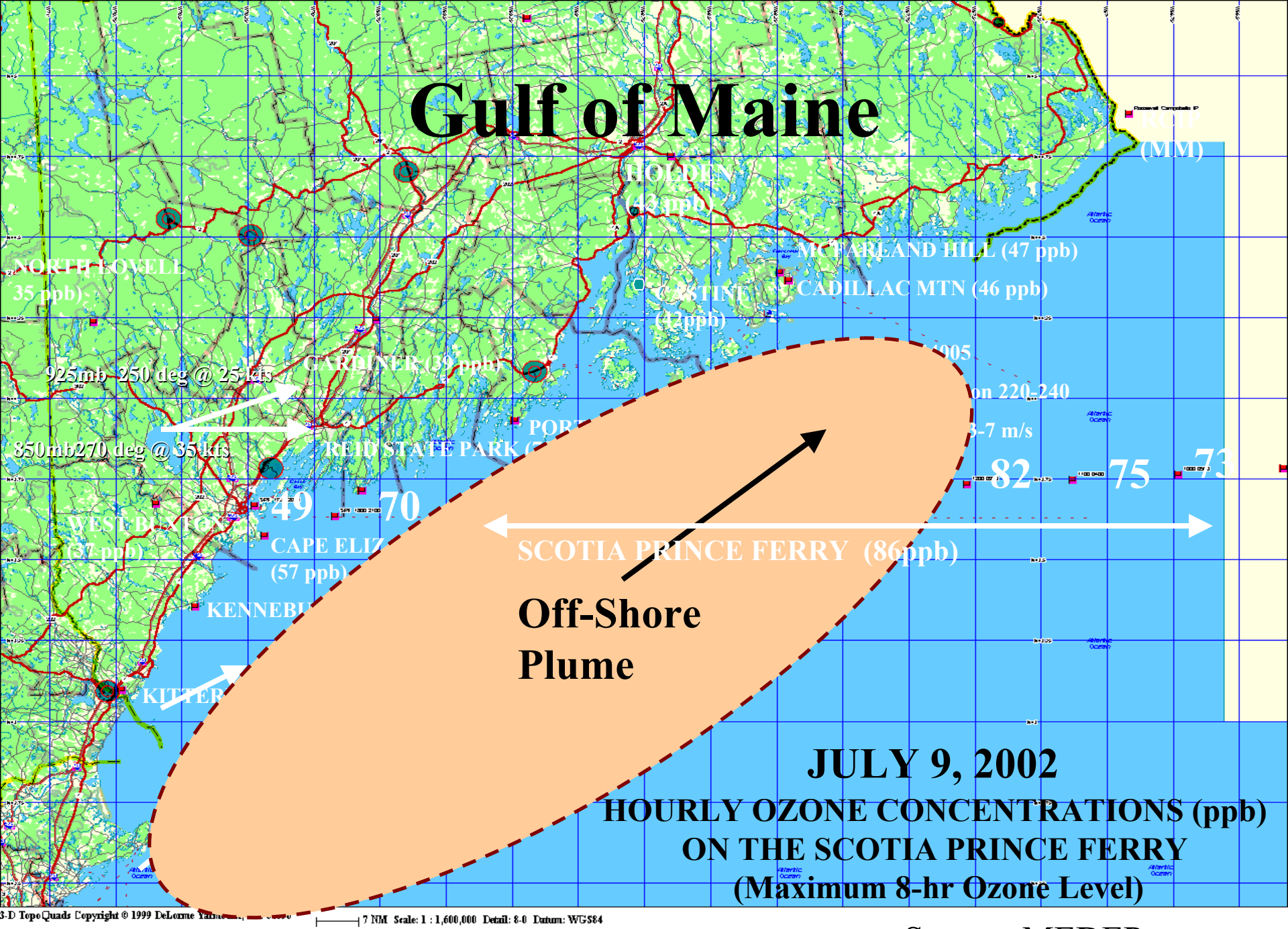
Source: MDE and UMD

Classic Low-Level Transport

1. Air pollution trapped under a low-level inversion over cool/cold ocean/bay water

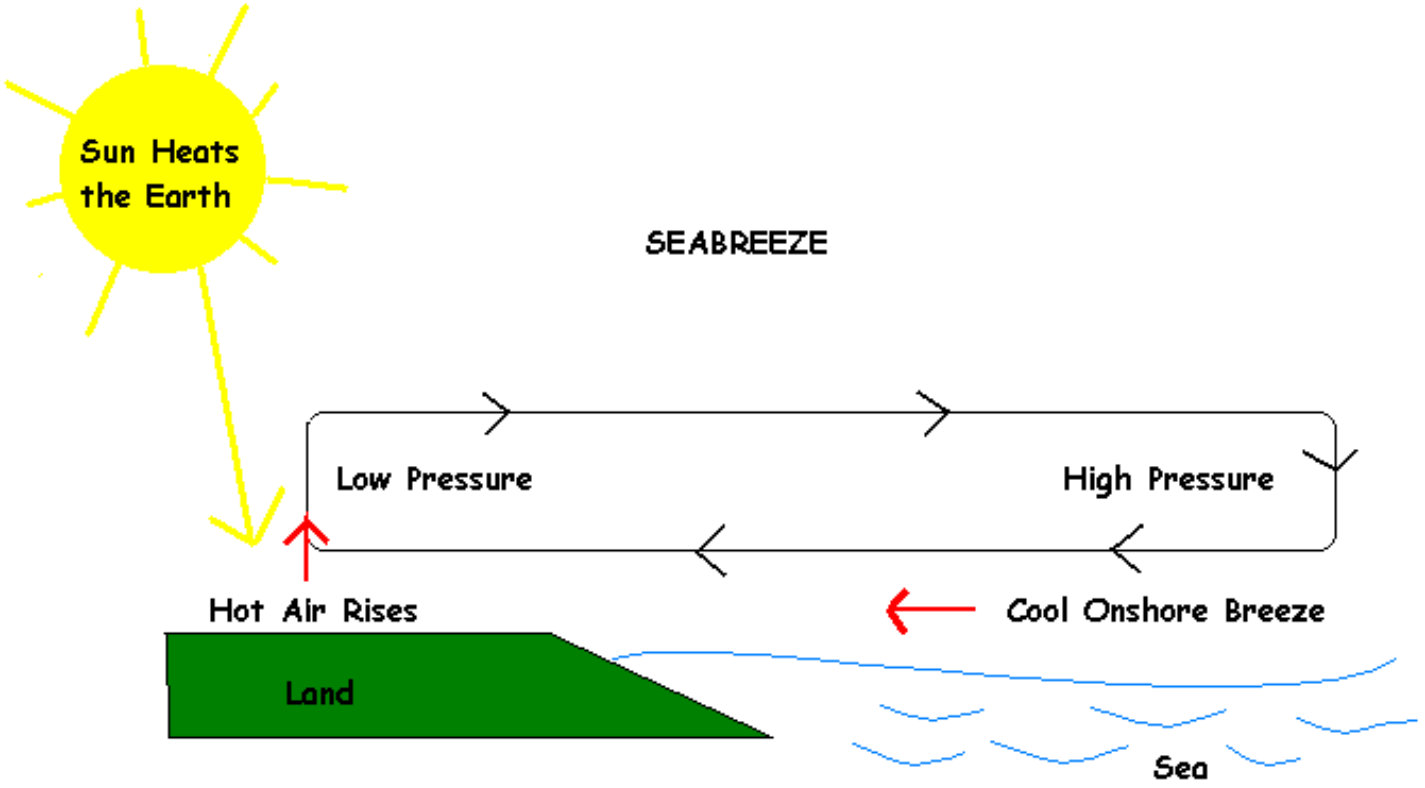
2. Pollution stays concentrated because it cannot mix upward

3. A late afternoon sea/bay breeze blows concentrated pollution on-shore



Source: MEDEP

Local Circulations (Seabreeze Transport)

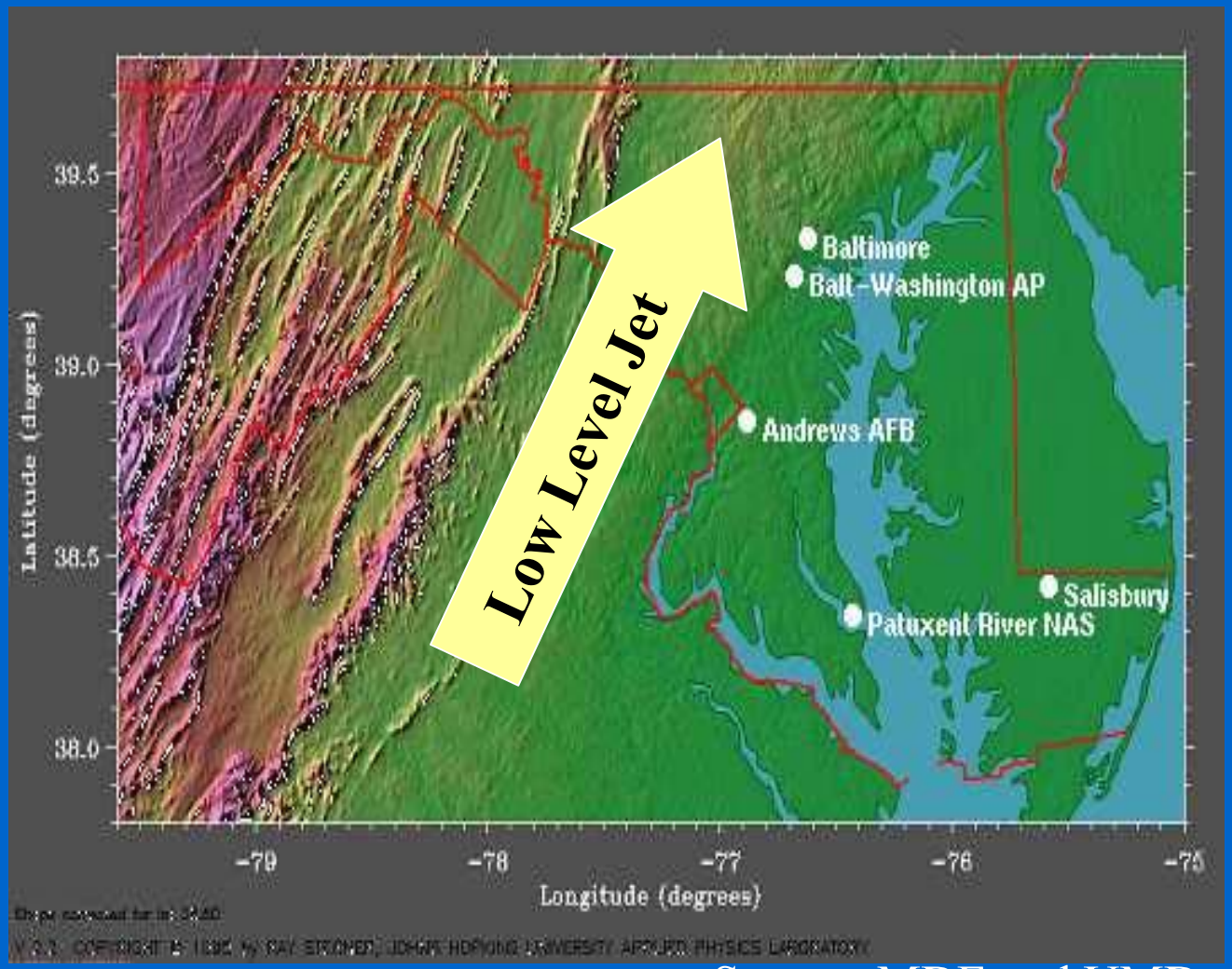


Source: NHDES

A Special Case of Low Level Transport

Low Level Jets

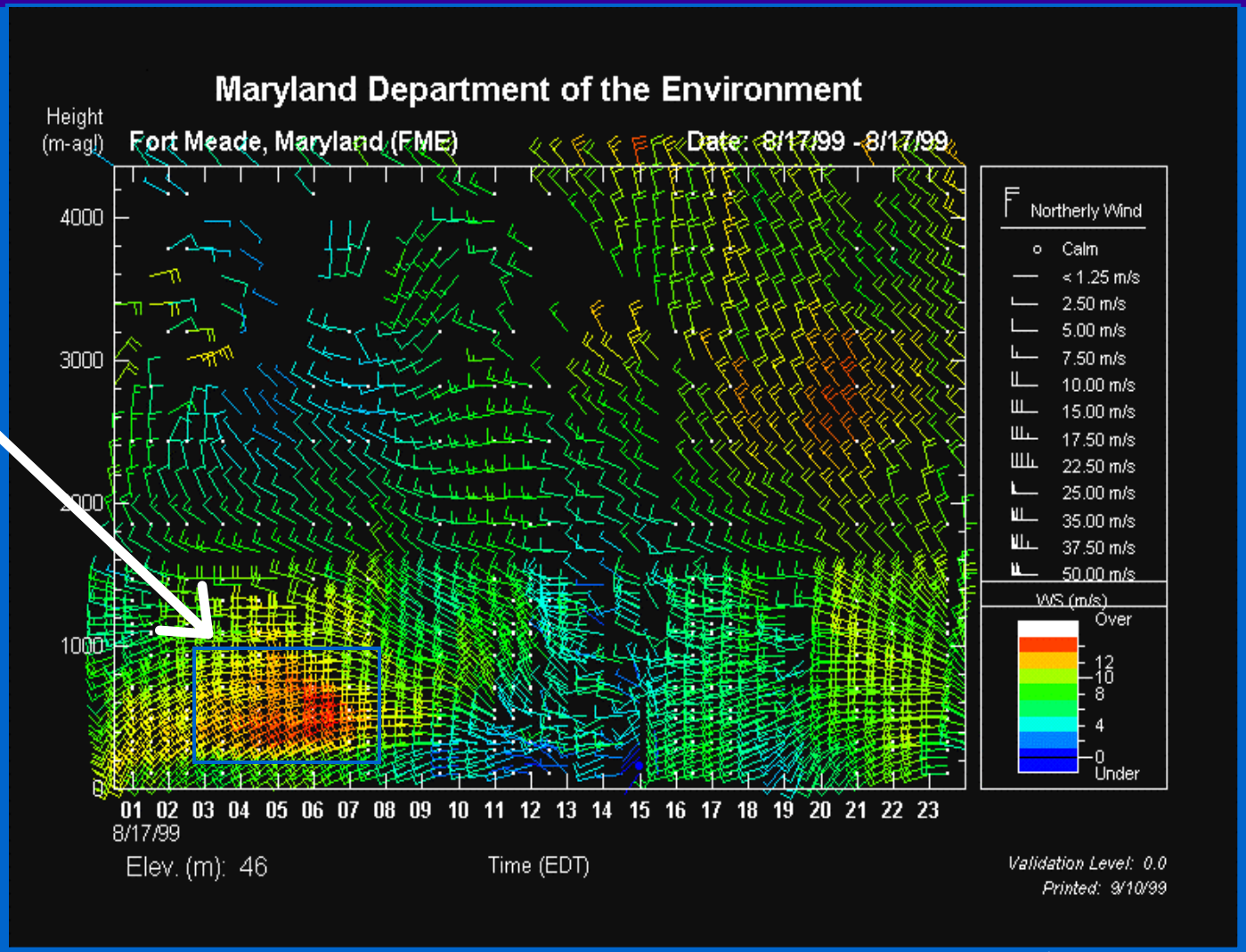
Form near, but just above the ground



Source: MDE and UMD

Profiler Identification of Low-Level Jet

- Low-Level Jets for early in the morning
- Forms 1000 and 2000 feet above the ground



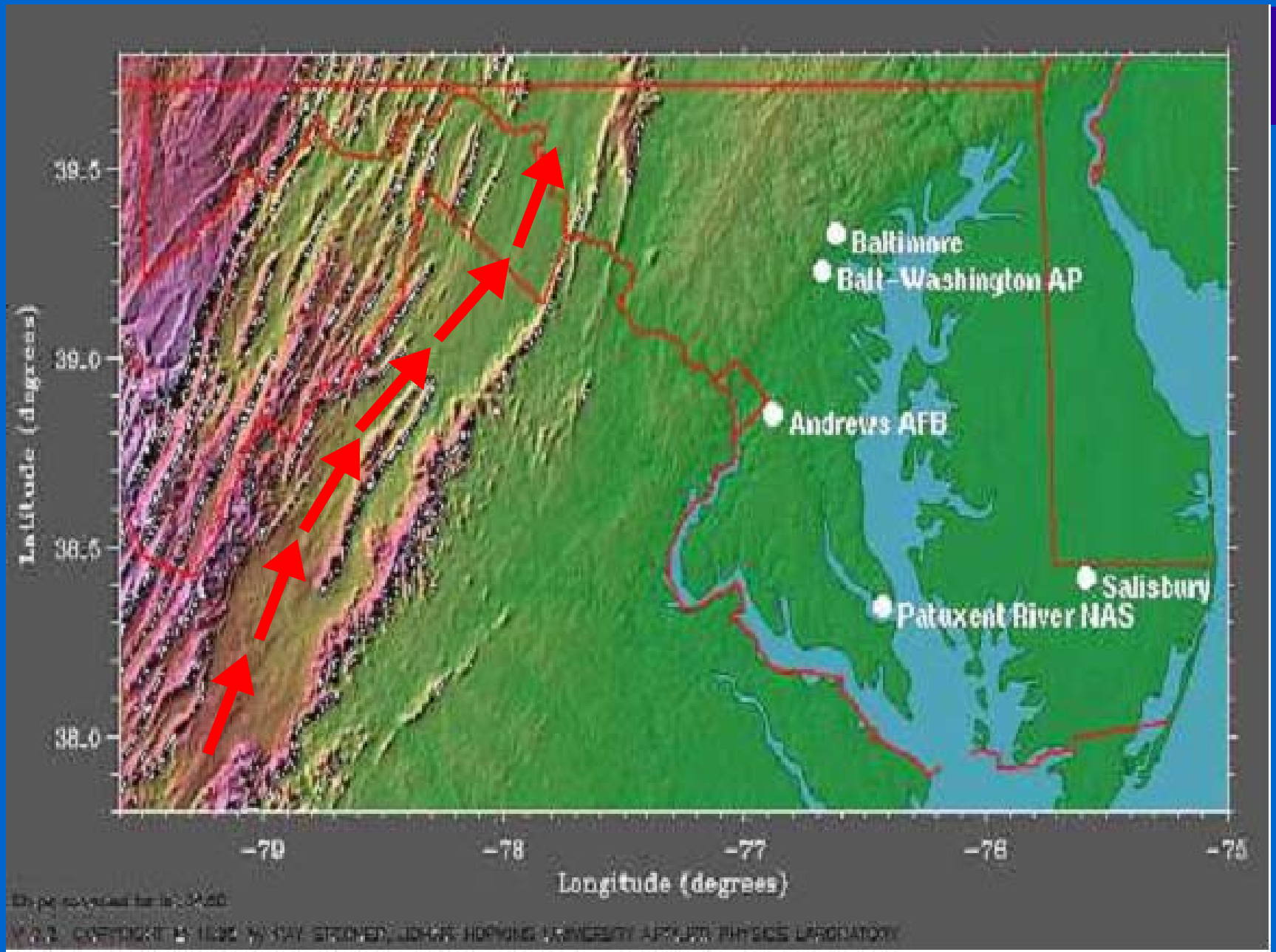
Ft. Meade, MD

Source: MDE and UMD

Mid-level Transport

- Air flow is low enough to be affected by large topographical features such as mountains and valleys.
- Flow is too high to be affected by low-level features such as trees, buildings, and small lakes.
- Typically, Mid-level transport follows mountain ridges, mountain and river valleys, and along large bodies of water.

Channeled Flow Up Mountain Valley



Will Transport Still Exist After the NOx SIP Call?

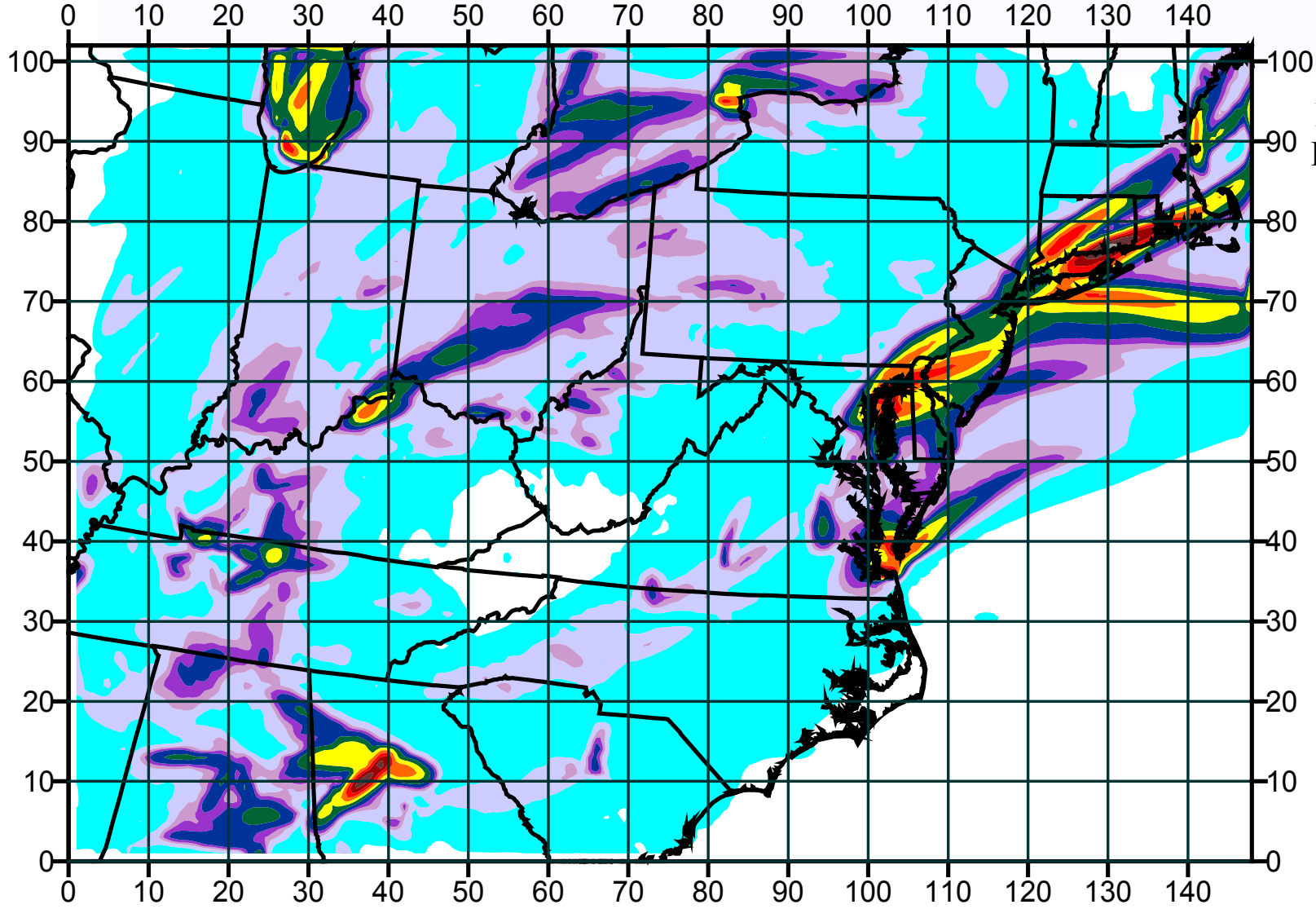
Many will tell you, "NO"

If so, the Northeast will no longer be forced to suffer from air pollution transport…

Instead, the region will be **"accepting air quality donations for episode enhancement."**

…And the story goes on…

Maximum 1-Hour Ozone
NOx SIP Call Emissions Domain-Wide

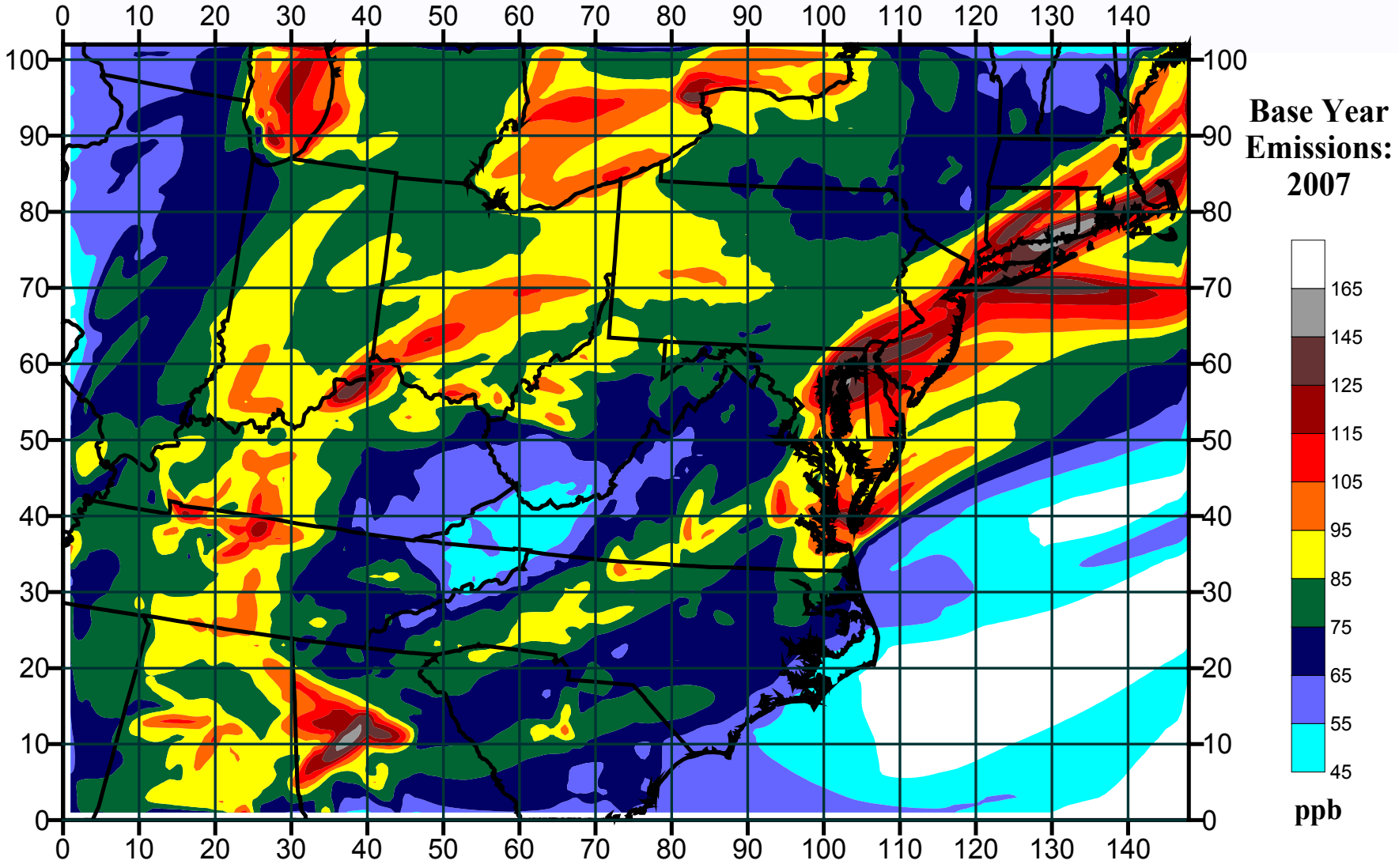


July 10-15, 1995 Meteorological Data

CALGRID 1.8
NHDES

8/01/02

Maximum 8-Hour Ozone
NOx SIP Call Emissions Domain-Wide



July 10-15, 1995 Meteorological Data

CALGRID 1.8
NHDES

8/01/02
22SIP-8MX.SRF

Clear Skies Benefit to the OTR

Fine Particle Concentrations (CSI - 2020)

Percent Change 2020 Base Case vs. Clear Skies

Percent Reduction

> 20
10 - 20
0 - 10
-10 - 0
-20 - -10
-30 - -20
< -30

(A positive percent reduction is a decrease, a negative percent reduction is an increase)

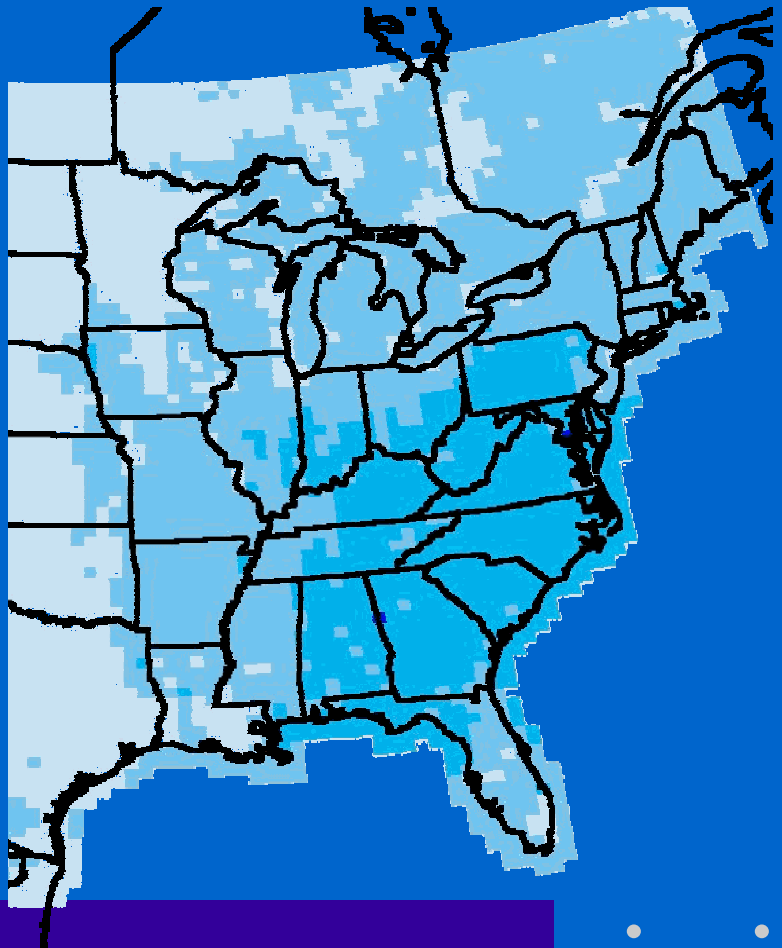
0-10% Benefit to North OTR

0-20% Benefit to South OTR

Source: EPA, July 1, 2002

Sulfate Deposition (CSI - 2020)

Percent Change 2020 Base Case vs. Clear Skies



Percent Reduction

< -60
- 60 - -30
- 30 - -15
- 15 - 0
0 - 15
15 - 30
30 - 60
> 60

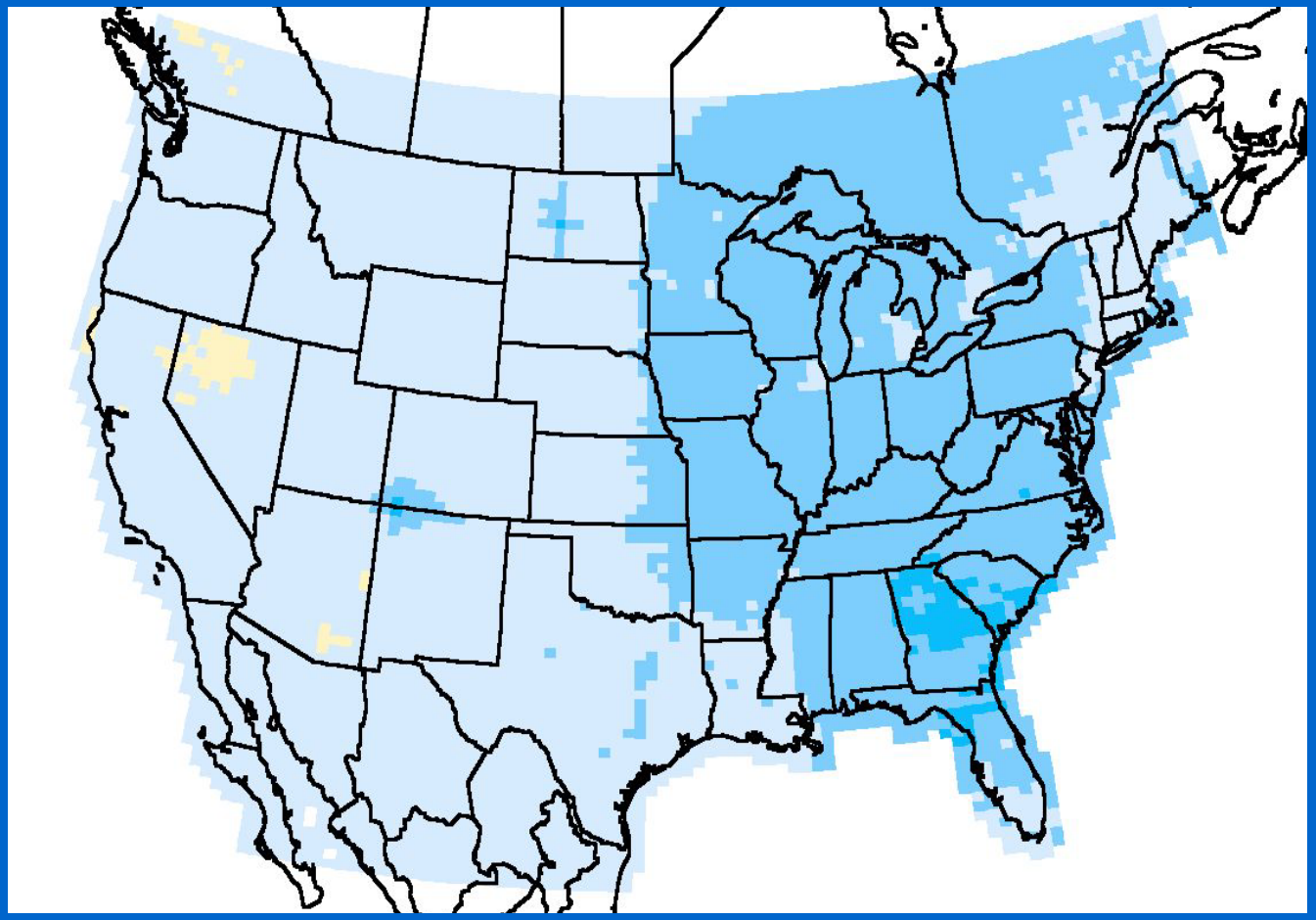
(A positive percent reduction is a decrease, a negative percent reduction is an increase)

0-30% Benefit to the OTR

Source: EPA, July 1, 2002

Nitrate Deposition (CSI - 2020)

Percent Change 2020 Base Case vs. Clear Skies



Percent Reduction

< -60
- 60 - -30
- 30 - -15
- 15 - 0
0 - 15
15 - 30
30 - 60
> 60

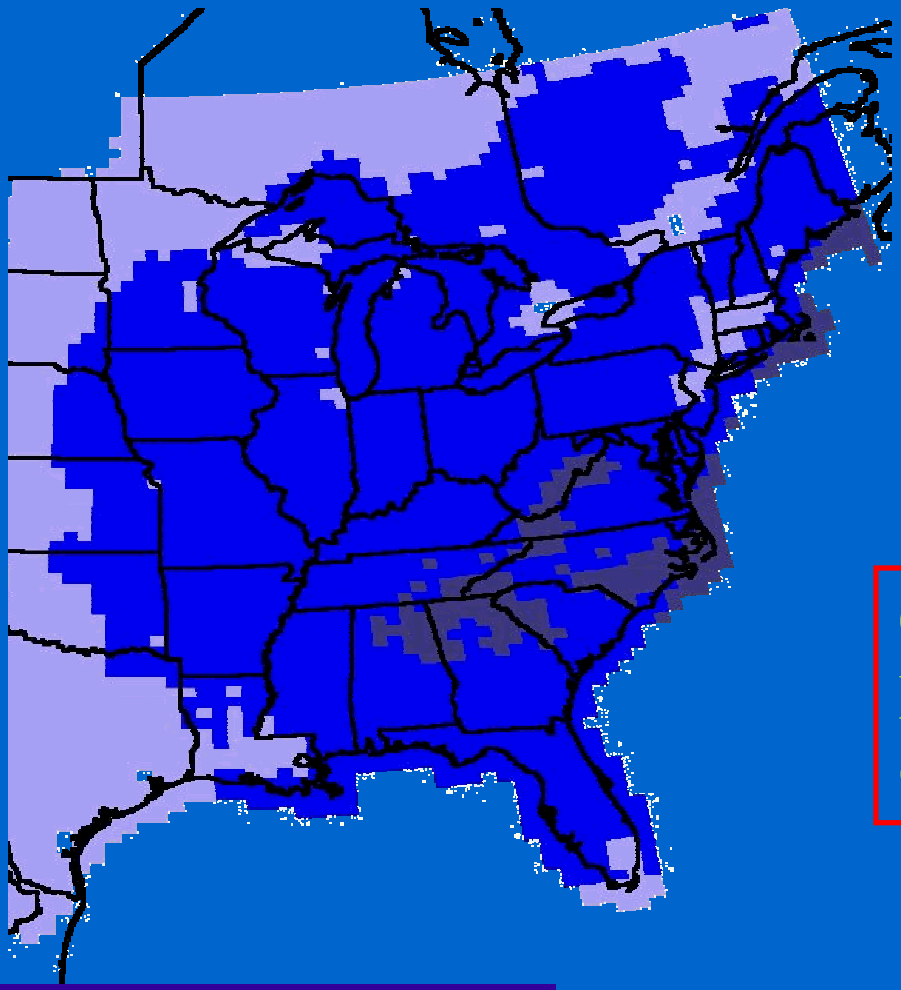
(A positive percent reduction is a decrease, a negative percent reduction is an increase)

0-30% Benefit to the OTR

Source: EPA, July 1, 2002

Regional Haze (CSI - 2020)

Deciview Change 2020 Base Case vs. Clear Skies



Deciview Change

-2 - -1
-1 - -0.5
-0.5 - 0.5
0.5 - 1
1 - 2
2 - 3
> 3

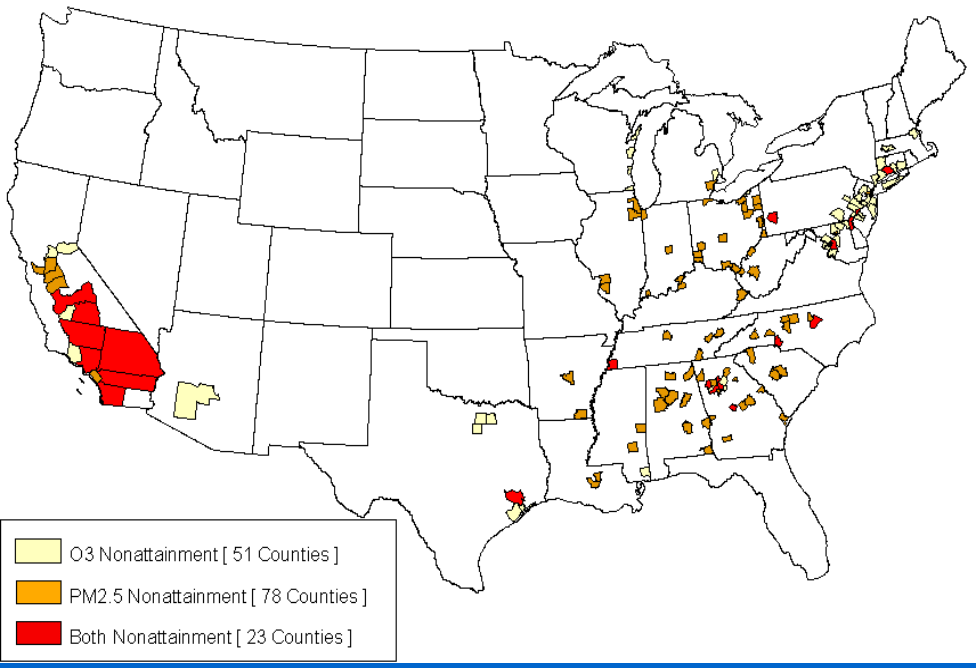
(On these maps, a positive change in deciviews is an improvement in visibility; a negative change in deciviews is a decrease in visibility.)

0.5-2 Deciview Benefit to the OTR

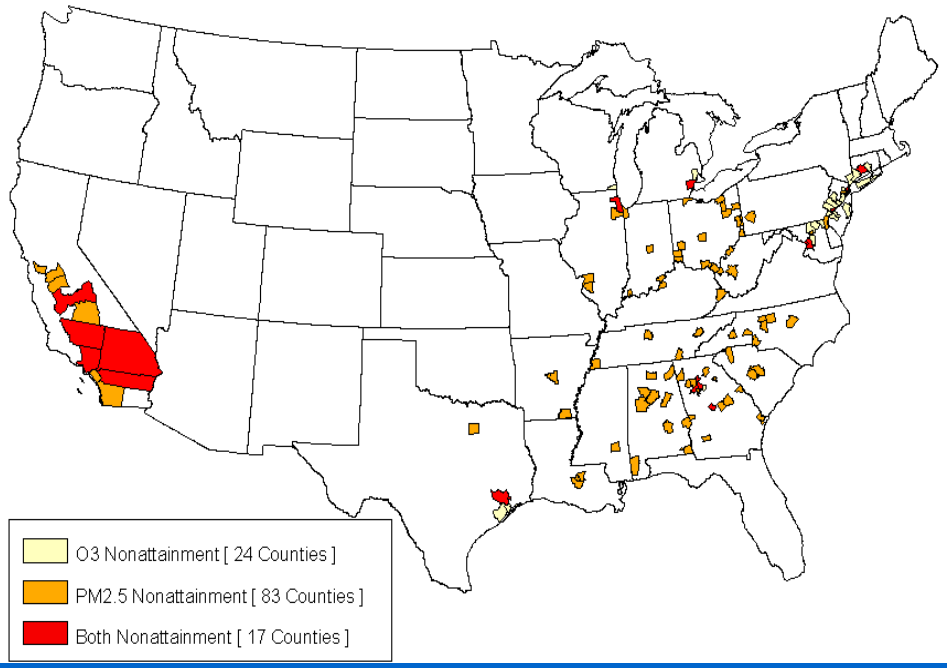
Source: EPA, July 1, 2002

O_3 and $PM_{2.5}$ Base 2010/2020

Base Case 2010



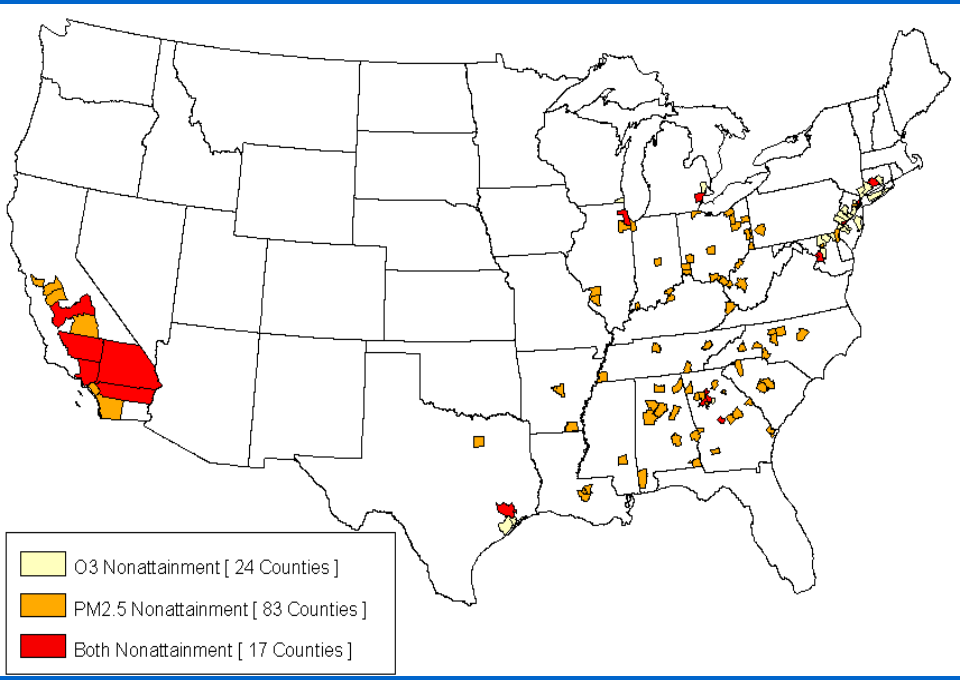
Base Case 2020



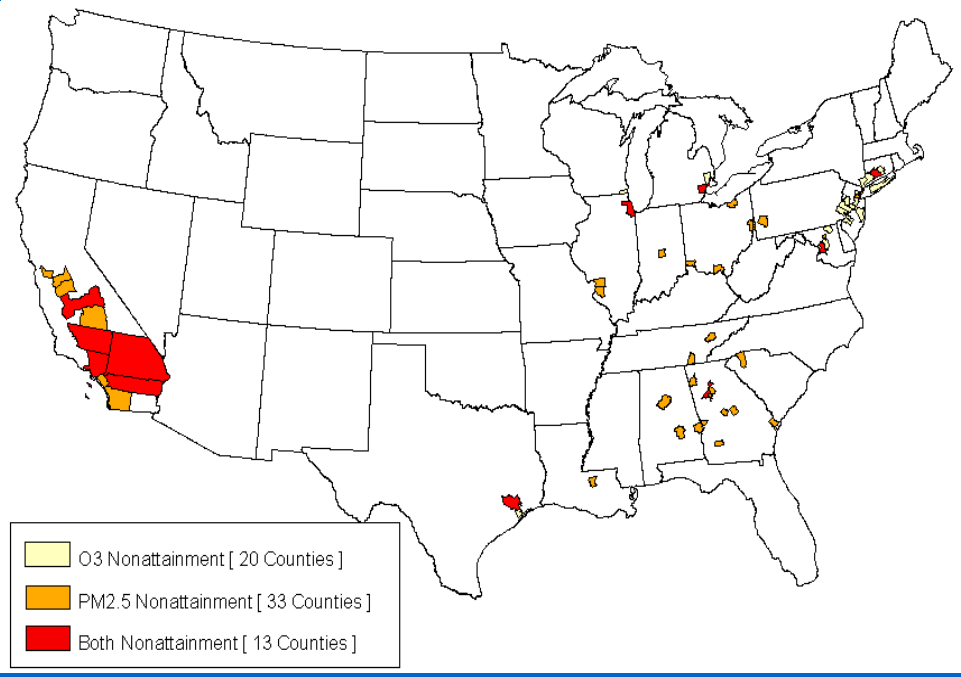
Source: EPA, July 1, 2002

O_3 and $PM_{2.5}$ Base vs CSI 2020

Base Case 2020

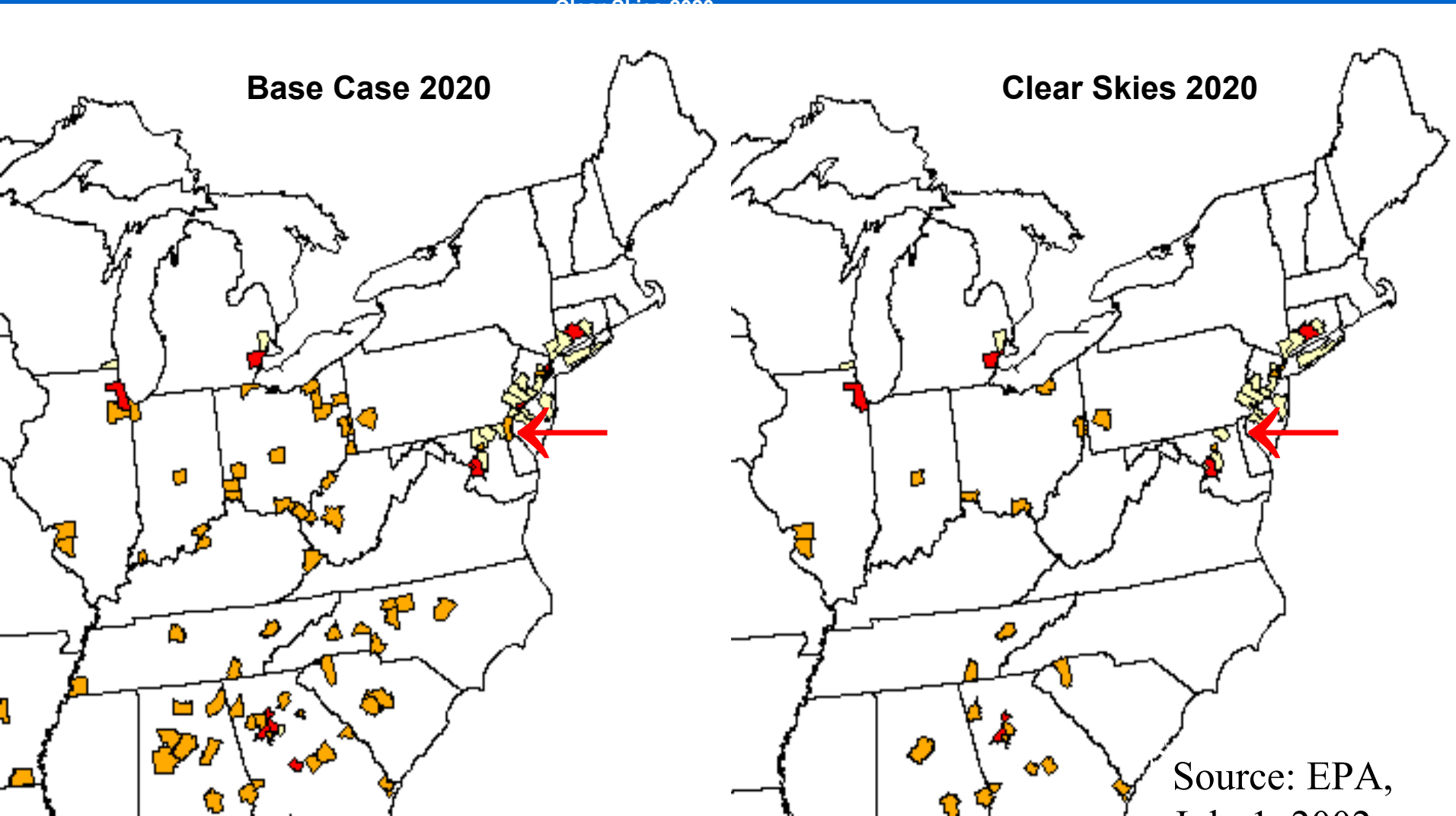


Clear Skies 2020



Source: EPA, July 1, 2002

The 4 County CSI Benefit to the OTR



NOx SIP Call and CSI By The Numbers

- Modeling indicates that 1-hour ozone will continue to be exceeded by 44% (181ppb) in the Northeast after the NOx SIP Call is implemented.
- Modeling also indicates that 8-hour ozone will exceed by 90% (162ppb).
- Animations of the NOx SIP Call clearly show continued transport into the Northeast.

NOx SIP Call and CSI By The Numbers

- Preliminary calculations indicate CSI will provide only about 6 to 11% additional NOx reductions by 2010 (OTR and nearby states).
- CSI falls well short of the 44% to 90% needed to fully attain ozone standards.
- Even the 2020 CSI reductions (~30% NOx) fall well short of what will be needed for 8-hour ozone. *(Remember 8-hr is more transport sensitive than 1-hr).*
- The rest are considered a "Local" problem.

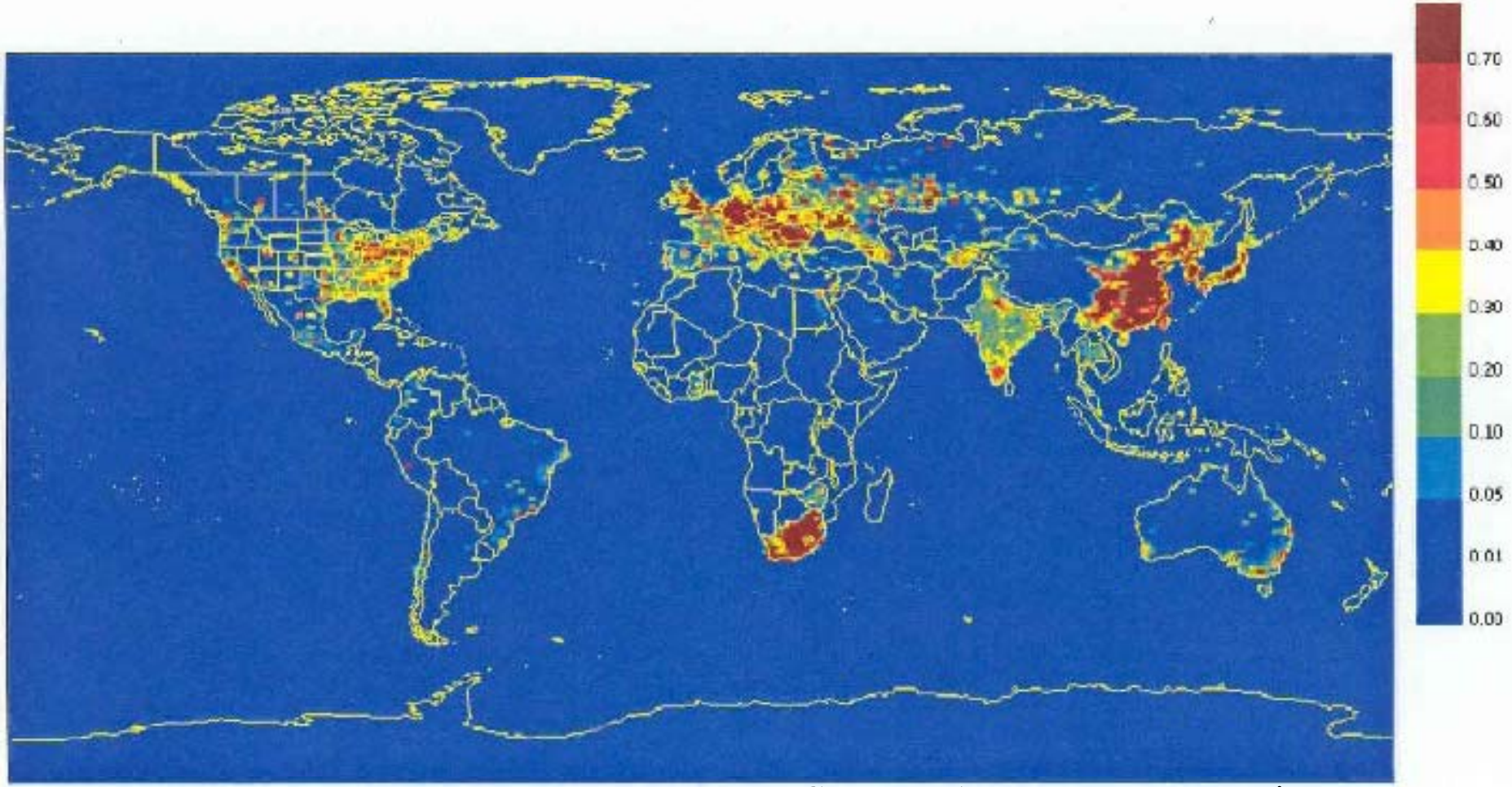
NOx SIP Call and CSI By The Numbers

- Additional inter-regional transport reductions may be very difficult to achieve between 2008 and 2018.
- Attainment dates for 8-hour ozone are likely to be around 2010.
- Areas failing to attain after 2008 may continue to fail and pile-up sanctions until 2018.
- Substantial CSI emission allowances will continue until 2059-2061 for NOx, SO_2, and mercury. How will this affect future PM and regional haze mitigation?
- Will Section 126 exist after CSI?

Little On Mercury…

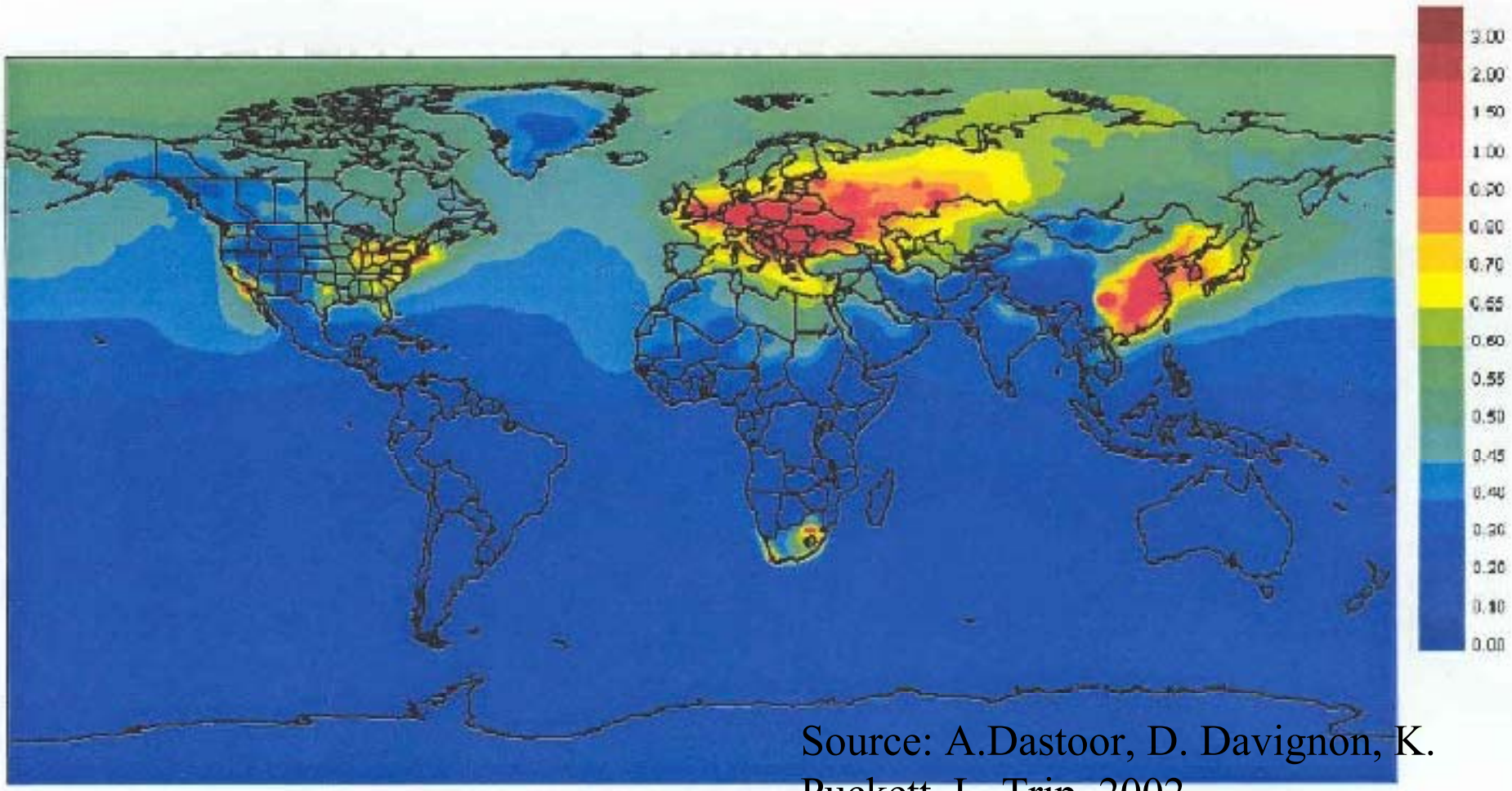
Mercury Emissions

Total Hg anthropogenic emission ton/yr
57% Hg(0) ; 30% Hg(II); 13% Hg(p)



Source: A.Dastoor, D. Davignon, K. Puckett, L. Trip, 2002

Mercury Concentrations



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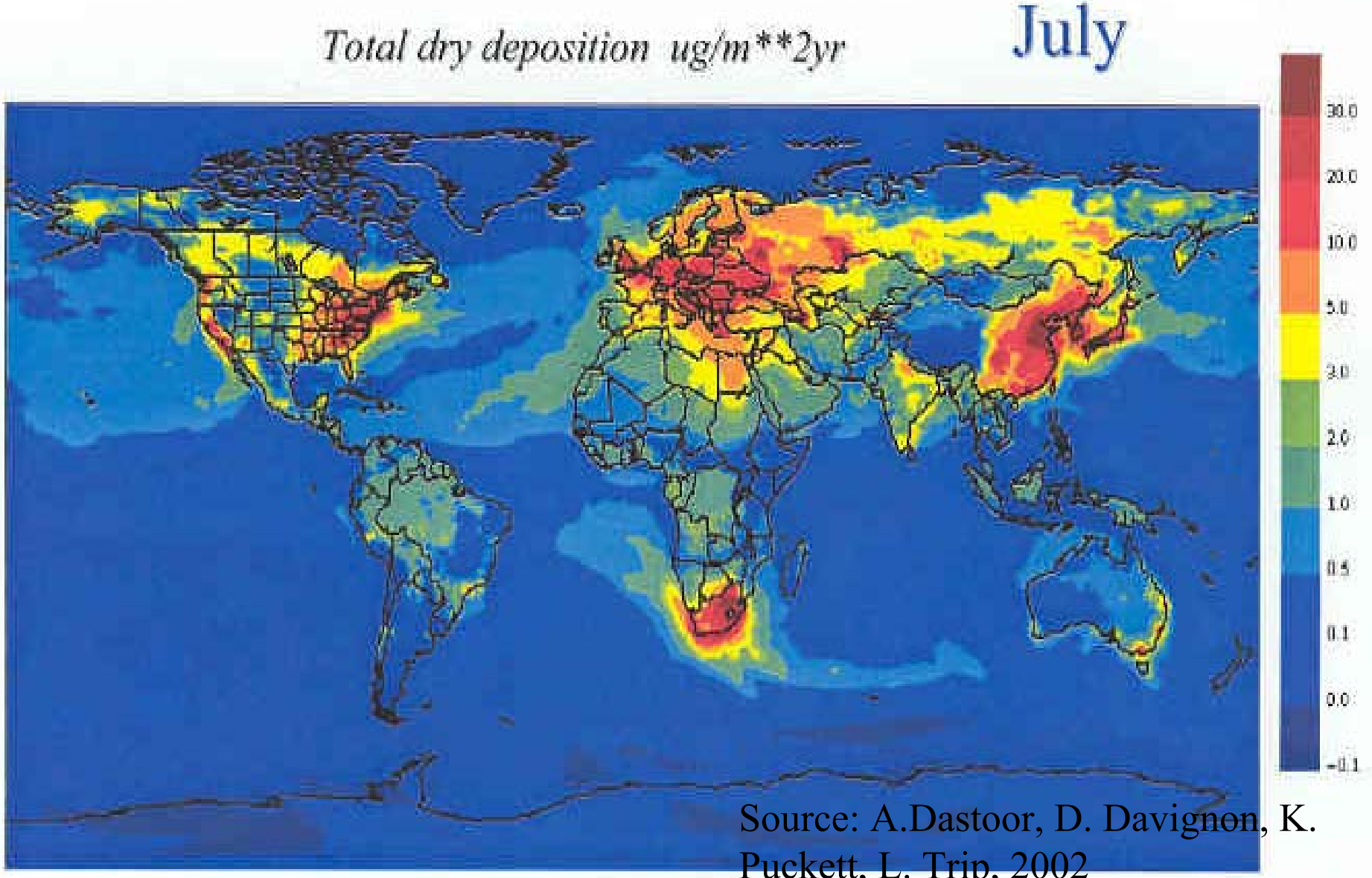
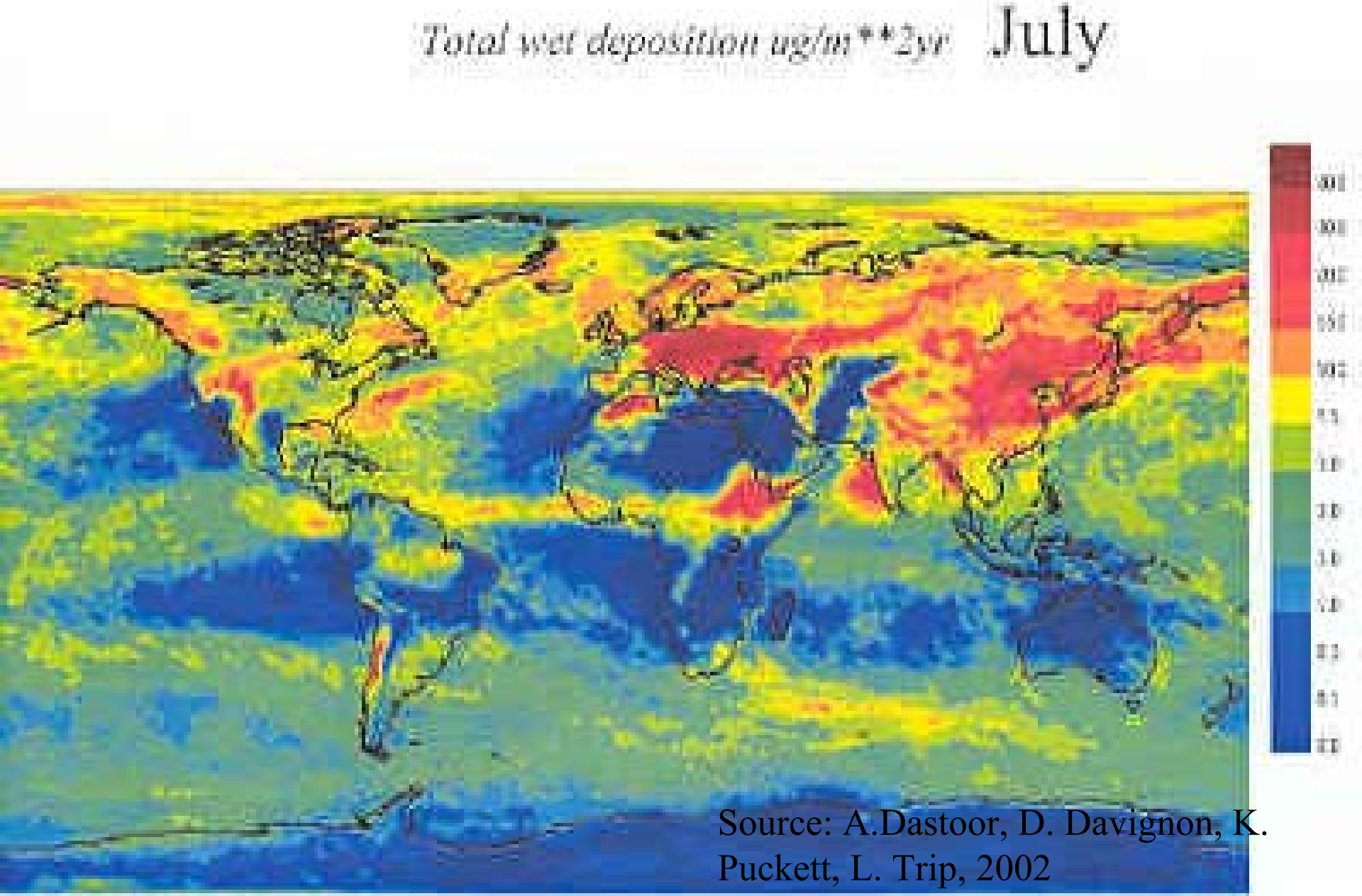
Mercury Dry Deposition



Source: A.Dastoor, D. Davignon, K. Puckett, L. Trip, 2002

Mercury Wet Deposition



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